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Vol XI (index) bound in vol X

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A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE,

&c. &c.

⁂ *The Public are reſpectfully informed that the Synoptic Tables may be had ſeparate.*

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A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE;
AND ITS
APPLICATION
TO THE
PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,

Of the National Institute of France, Counsellor of State, Professor
of Chemistry at various Public Establishments, Member
of many Academies, &c.

IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES, IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,

BY WILLIAM NICHOLSON.

VOL. I.

LONDON:
PRINTED FOR CADELL AND DAVIES, STRAND; LONGMAN
AND REES, G. AND J. ROBINSON, AND J. WALKER,
PATERNOSTER-ROW; VERNOR AND HOOD, POULTRY;
CLARKE AND SONS, PORTUGAL-STREET; CUTHELL
AND MARTIN, AND OGILVY AND SON, HOLBORN;
AND S. BAGSTER, STRAND.

1804.
W. Flint, Printer, Old Bailey,

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THE

TRANSLATOR's PREFACE.

I NOW preſent the ſcientific world with a Tranſlation of the moſt extenſive Chemical Treatiſe at preſent in being; compoſed by an Author whoſe continued labours and reſearches are too well known to require any eulogium from me on this occaſion. An entire generation of Chemiſts, who have imbibed their firſt notions of this Science from his Works, in every part, and by every language in Europe, can bear teſtimony to the happy perſpicuity, with which he arranges and communicates the important doctrines upon which it is founded. The work would have appeared ſooner, notwithſtanding its conſiderable magnitude, if my ſtate of health had not been almoſt inceſſantly broken, ſo as to put the rapid proſecution of buſineſs out of my power. I ſhall therefore detain the Reader no longer with any preliminary diſcuſſion; but ſhall give ſome notices of the principal diſcoveries in Chemiſtry, made ſince the publication of theſe Elements.

There is perhaps no ſubject in the extenſive range of the ſcience of Chemiſtry, on which practical writers are leſs agreed than they are on the nature and number of ſimple bodies. Fourcroy admits thoſe only into that claſs which have relation to combuſtion, while a conſiderable number of Chemiſts include amongſt them all thoſe which cannot be decompoſed or reduced to their conſtituent principles, however analogous they may be to bodies which are known to be compounds. Dr. Thomſon, of Edinburgh, in the Remarks on Combuſtion, with which he favoured me for publication in the Journal of Natural Philoſophy, Chemiſtry, and the Arts, is diſpoſed to reduce the number of the ſimple combuſtibles admitted by Fourcroy, and to exclude gold, ſilver, and mercury. His reaſons are, "that they do not burn in air, how high ſoever the temperature is; neither do they detonate with red-hot nitre, nor exhibit any appearance of combuſtion in oximuriatic acid gas; though this laſt body oxidates them with great rapidity."

On the ſubject of Light, which has been very conciſely treated by our Author, many excellent memoirs have appeared ſince the publication of his Work, or with which he ſeems to have been unacquainted. Among theſe, Dr. Hulme's papers, in the Philoſophical Tranſactions for 1800 and 1801, on ſpontaneous and imbibed Light, are well calculated to elucidate its real nature and properties. One of his obſervations on azote as a ſupporter of Light, coupled with Dr. Thomſon's on the ſame principle as a ſupporter of combuſtion, ſhould induce further reſearches into the qualities of this gaſeous body. Dr. Hulme ſhows that it is capable of preſerving the brilliancy of the light emitted by fiſhes, and in ſome caſes of renovating it when nearly expired: Dr. Thomſon obſerves that it is the *baſe* of four out of five compound ſupporters of combuſtion, and ſuſpects its exiſtence in the fifth. The ingenious experiments of Dr. Herſchell on the illuminating powers of the rays of light, publiſhed in the Philoſophical Tranſactions for 1800, and Dr. Wollaſton's, in the ſame collection for 1802, on the refraction and diſperſion of light, are highly intereſting, and tend greatly to explain the nature of ſolar light.

It is a queſtion which cautious Philoſophers can by no means conſider as decided, whether the phenomena of heat and light be cauſed by the preſence of ſome body or bodies poſſeſſing peculiar properties,—or by certain motions to which moſt, if not all bodies, or their parts, are capable of being ſubjected; or in other words, whether heat and light, or either of them, do conſiſt in a peculiar matter, or in a motion, either of the parts of bodies, or of ſome generally diffuſed fluid, ſuch as the ether of Newton, &c. Many Chemiſts appear to have proceeded with too much rapidity, when they have conſidered light and heat as decidedly capable of entering into combination like other bodies, and of being diſengaged by the action of the affinities. On this extenſive ſubject it is impoſſible to ſay much on the preſent occaſion. The doctrine of light and heat, as cauſed by, or conſiſting of vibratory motions, has been ſtrongly ſupported by the late experiments and obſervations of Count Rumford, in the Philoſophical Tranſactions, and by the learned and acute diſcuſſions of Dr. Thomas Young, in the ſame collection; and Mr. Henry, in the Mancheſter Memoirs, vol. v. has given a detail of the facts and reaſons that we at preſent poſſeſs in defence of the oppoſite opinion.

The effect of heat on bodies in the liquid and gaſeous ſtate has been very accurately inveſtigated, and many new facts have been eſtabliſhed. The ingenious inveſtigations of Mr. Dalton, on the dilation of gaſes and vapours are inſerted in the Mancheſter Memoirs, v. 595, and in various communications to my Journal. The concluſion he draws from them is, that all the gaſes are equally dilatable and condenſable by change of temperature; and that the ſame reſult is applicable to vapour, provided the temperature be ſufficiently elevated to counteract its tendency to return to the liquid ſtate. Experiments on the ſame ſubject, and producing a ſimilar reſult, were alſo ſubſequently made by Cit. Guy Luſſac. His paper is in the Annales de Chimie, v. 43. Mr. Davy has publiſhed a method of eſtimating the changes of volume in gaſes, which removes the neceſſity of laborious and complicated calculations. It will be found in the Journals of the Royal Inſtitution.

Two papers on the conducting power of fluids, have been tranſmitted to me by Mr. Murray, of Edinburgh, and are inſerted in the Journal of Natural Philoſophy, &c. vol. i. 165—241; in which he demonſtrates that heat is conducted *downwards* in fluids, and conſequently does not wholly depend upon the motions cauſed by the temperature of the lower part of the fluid being firſt heated, and its ſpecific gravity being ſo changed as to cauſe it to aſcend, as was ſhown in the experiments of Count Rumford. Hence he concludes that fluids are real conductors of heat. The ſame truth was alſo eſtabliſhed by other very acute and ingenious experiments, by Dr. Thomſon, and likewiſe by myſelf, with a different apparatus, both which are to be found in the ſame Journal.

The exiſtence of azote in the natatory

veſſels of the carp, which Fourcroy points out as one of the ſources from which it may be obtained pure, is denied by Mr. Accum, who aſſerts that the air-bladder of the *living* fiſh is filled with atmoſpheric air. Probably thoſe examined by the French Chemiſt were in an incipient ſtage of the putrefactive proceſs, and might have experienced ſuch a change from that cauſe.

An opinion of Mr. Harrup, of Chobham, reſpecting the renovation of atmoſpheric air deſerves to be noticed in this place.* He conſiders the oxigen emitted by vegetables to be inadequate to ſupply the quantity conſumed in the various operations of nature, which depend on its abſorption; and that, from the circumſtance of it's being equally diffuſed over every part of the globe, it muſt have a ſource equally extenſive, which is not the caſe with vegetables, theſe being limited to a very ſmall portion of the whole ſurface. He is of opinion that a direct chemical affinity exiſts between azote and oxigen, and that water is the ſource whence this vital principle is abſorbed, and he relates an experiment in which nitrogen gas confined over water, and expoſed to the open air, acquired an increaſe of volume of nearly one-fifth of the whole, and, on examination, exhibited all the properties of atmoſpheric air. This ſubject is worthy of further inveſtigation.

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* Philoſophical Journal, v. 184.

The combination of hidrogen with metals, which has been frequently ſpoken of by Chemiſts, as poſſible, and of the exiſtence of which, inſtances have been cited by moſt of them, without any actual examination of the compound, has given birth to a Memoir of Profeſſor Tromſdorff, inſerted in the Proceedings of the Royal Academy of Berlin, on the Chemical analyſis and properties of arſeniated hidrogen gas. In this paper the production, properties, and decompoſition, of the compound are inveſtigated, and its habitudes with other bodies are ſtated with preciſion.

The combination of phoſphorus and carbon, which is ſtated by Fourcroy not to be yet known, is ſhown by Cit. Steinacher, in the Annales de Chimie, xlvii. 97, to exiſt in every caſe in which phoſphorus is produced. He contends that it is impoſſible to free it wholly from the charcoal, and that what has hitherto been conſidered as pure phoſphorus, is, in fact, a ſort of gangue, or phoſphuret of carbon. The ſame Chemiſt alſo notices a new compound of phoſphorus and oxigen, which he denominates white oxide of phoſphorus at the *minimum*. Its production and properties are different from the white oxide uſually formed by the action of water, which he calls white oxide of phoſphorus, at the *maximum*.

Dr. Thomſon has beſtowed much pains in the inveſtigation of the properties of ſulphur and its three ſtates of combination with oxigen. His excellent paper on this ſubject is inſerted in the Journal of Natural Philoſophy, &c. vol. vi. 92; and affords a comprehenſive view of the two combinations of theſe bodies, which have been but inaccurately treated on by former writers, namely, the ſulphurous acid and the oxide of ſulphur. The ſulphuric acid has been already ſo well deſcribed as to make any new analyſis unneceſſary. From the wellconducted experiments he has made on the other two, it reſults that ſulphurous acid is compoſed of 68 ſulphur, and 32 oxigen, in the 100 parts; and that the oxide of ſulphur contains 97.6 ſulphur, and 2.4 oxigen. In the proſecution of his enquiries he obtained an acid hitherto unnoticed, which proceeded from the action of the oximuriatic acid on ſulphur. He has called it ſulphurated muriatic acid, and has deſcribed its properties with his uſual accuracy.

The theory of combuſtion, by the ſame Author, has been mentioned before. He admits the merit of Lavoiſier's theory, but denies that it is completely ſatisfactory; nor is he diſpoſed to allow that the combination of a body with oxigen and the act of combuſtion are the ſame. In reviewing the bodies which occupy the attention of Chemiſts, he divides them into three claſſes, viz. Combuſtibles, Supporters of Combuſtion, and Incombuſtibles. The combuſtibles he ſub-divides into ſimple and compound combuſtibles, and combuſtible oxides. In this conſiſts one eſſential point of difference between his theory and that of the French Chemiſts; they conſider oxides as bodies already burned, either wholly or in part; he conſiders them as bodies capable, in ſome caſes, of ſupporting cumbuſtion, and then denominates them partial ſupporters. The ſupporters of combuſtion are oxigen, either alone, or united to ſome baſe; in four caſes of which deſcription out of five, this baſe, as was noticed above, is azote. In all caſes of combuſtion a combuſtible and a ſupporter muſt be preſent, and the compound formed by their reciprocal action, which he calls a product of combuſtion, muſt be water, an acid, or a metallic oxide; and, according to this theory, light and heat muſt be evolved. This laſt condition diſtinguiſhes combuſtion from oxigenation. It would extend this ſubject too far to enter into all the points of difference between the two theories, it will be ſufficient to obſerve here, that he conſiders the caloric as a component part of the oxigen, and the light as being contained in all combuſtibles; and that the union of the diſengaged portions of theſe bodies during combuſtion produces fire. He alſo contends that fire may be produced from the action of partial ſupporters with incombuſtible bodies, and proves the exiſtence of light in ſome of the earths and alkalis; the caloric being furniſhed by the ſupporter. This proceſs he calls ſemi-combuſtion.

With reſpect to the combuſtion of metals, Profeſſor Tromſdorff, in his Hiſtory of Galvaniſm, p. 122, has ſhown that they are combuſtible in non-reſpirable gaſes, by means of the Galvanic ſpark.

In the Philoſophical Tranſactions for 1802, is a paper of Mr. Chenevix, on the Muriatic Acid, and its combination in the three ſtates of ſimple, oxigenized, and hyper-oxigenized muriatic acid. After ſtating the labours of former Chemiſts, and the reſults of his own experiments, he heſitates on the propriety of conſidering muriatic acid as a compound of oxigen with the muriatic radical, or as a compound of which oxigen is one of the component parts; he ſeems inclined to believe that what is called muriatic acid, is really the radical, and that the oxigenized and hyper-oxigenized acids ſhould be called, in conformity with the received nomenclature, muriatous and muriatic acids.

A ſimilar obſervation is made by Cit. Curaudau, in a Memoir on the Nature and

New Properties of Pruſſic Acid, inſerted in the Annales de Chimie, xlvi. 148. He is of opinion that what is commonly called Pruſſic Acid Gas, is only the Pruſſic Radical, and propoſes to call it Pruſſire. Dr. Schaub, of Caſſel, gives a new method of obtaining Pruſſic acid, in a ſtate of abſolute purity, by diſtilling a mixture of two parts of Pruſſian blue, one of ſulphuric acid, and one of water.

Profeſſor Tromſdorff has publiſhed, in Van Mons's Journal de Chimie et de Phyſique, p. 213, an account of a new ſpecies of gas, conſiſting of carbon, hidrogen, and phoſphorus. He calls it Phoſphorated Carbonated Hidrogen Gas, and promiſes additional details as to its nature. His experiments on arſeniated hidrogen gas have been already noticed.

Profeſſor Prouſt's Obſervations on Oily Hidrogen, which he obtained from the diſtillation of olive oil, is to be found in the Journal de Phyſique, Germinal, An. xi. He throws conſiderable light on the intimate nature of vegetable oils, and on the effects produced in them by heat.

In Van Mons's Journal is a Memoir of Ekeberg, on the properties of yttria compared with thoſe of glucine.

The properties of the ſo called Aguſtine Earth are deſcribed by Tromſdorff in the Annales de Chimie, xxxiv. 133, and the proceſs for ſeparating it from its native combinations was publiſhed by Göetling, in a work entitled *Practiſche Anleitung zur zerlegenden Chimie.* Its analyſis is to be found in Accum's Practical Analyſis of Minerals, juſt publiſhed. Later experiments by Vauquelin, and by Chevenix, have ſhown that it is merely phoſphate of lime.*

Tromſdorff has ſhown the method of cryſtallizing lime. It is inſerted in the Journal der Pharmacie, vol. ix. part i. p. 108.

Mr. Chenevix has made ſome very intereſting experiments on the chemical affinities of the earths for each other. They are contained in a Memoir in the Philoſophical Tranſactions for 1802. He takes occaſion in it to controvert Berthollet's poſition, that the energy of chemical affinity is governed by the maſs of the decompoſing ſubſtance.

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* Philoſophical Journal, vii. 118.

Mr. Chenevix's experiments on oxigenized and hyper-oxigenized muriates have been noticed above. Thoſe of Cit. Robert on the inflammation of combuſtible bodies, combined with ſur-oxigenated muriate of pot-aſh, by contact of ſulphuric acid, are inſerted in the Annales de Chimie, Frimaire, An. xi. They are accompanied by remarks and new experiments made by Citizens Cadet and Boullay. The reſults are very intereſting, and the proſecution of the enquiry ſeems likely to lead to the diſcovery of ſeveral new facts, reſpecting the intimate nature of combuſtible bodies.

Mr. Funcke, apothecary, at Lintz, in Germany, has publiſhed in Scherer's Journal, ix. 59, a new method of preparing phoſphate of ſoda, which ſeems preferable to that now in uſe. It conſiſts in ſaturating the exceſs of lime in calcined bones, with dilute ſulphuric acid. The remaining phoſphate of lime is then diſſolved in nitric acid, to which ſolution, ſulphate of ſoda is added, and the nitric acid is recovered by diſtillation. The phoſphate of ſoda is then ſeparated from the ſulphate of lime by affuſion and cryſtallization.

In the claſs of metals ſeveral diſcoveries of great importance have been made. Mr. Ekeberg has announced a new metal which he extracted from the gadolinite, and from a mineral, to which he propoſes to give the name of yttro-tantalite, from its containing the new earth yttria, as well as the metal which he calls Tantalium. The method of obtaining the metal, and its phyſical and chemical properties, are inſerted in the Journal of Van Mons, and copied into the Journal de Phyſique, lv. 281.

Mr. Hatchett has alſo added a new acidifiable metal to thoſe before known, which he has named Columbium. His paper is in the Philoſophical Tranſactions for 1802. The mineral from which it was extracted, came from the mines of Maſſachuſetts, in North America. It has not yet been obtained in its metallic ſtate.

Another ſubſtance has been announced in the London Journals, which is deſcribed as a new noble metal, under the appellation of Palladium, but as its owner has not thought proper to publiſh the details of its hiſtory, it reſts at preſent wholly on his credit; at the ſame time it is but juſtice to him to ſay, that he has ſubmitted it to the teſt of experiment, and has depoſited a ſum of money (twenty pounds) in the hands of the vendor, to be paid to any Chemiſt who ſucceeds in making a ſimilar metal, by uniting any of thoſe we already poſſeſs; Charles Hatchett, Eſq. F. R. S. and Edward Howard, Eſq. F. R. S. have conſented to join myſelf in the award of this prize, reſpecting which ſee the Philoſophical Journal, vii. 75,159.

The reduction of the oxide of titanium to the metallic ſtate, which has hitherto been attended with much difficulty, has been accompliſhed by Profeſſor Lampadius, by means of charcoal only. His proceſs is inſerted in Scherer's Journal, ix. 49--72. The oxide he operated on was that obtained from the decompoſition of gallate of titanium, by pot-aſh or ſoda.

Doubts have exiſted among Chemiſts of the firſt abilities, reſpecting the magnetic properties of nickel and cobalt. Many have been of opinion that this quality was communicated by a ſmall portion of iron, which could not be wholly ſeparated from them. In this number was Mr. Chenevix, who made ſeveral experiments to free nickel from iron, and thought he had ſucceeded by ſhowing that its magnetic properties were loſt, but he has ſince found reaſon to change his opinion, and in a paper which he permitted me to publiſh in the Journal of Natural Philoſophy, &c. vol. iii. 286, he has made it appear that the loſs of the magnetic properties was to be attributed to the preſence of arſenic. It might be a ſubject worthy the attention of experimental Chemiſts, to enquire if arſenic has the ſame effect on iron, or, if not, what are the differences in the qualities of the metals, which admit of that influence in the one caſe, and not in the other.

The experiments and obſervations of Mr. Howard, on ſtony and metalline ſubſtances, ſaid to have fallen on the earth, and on native iron, inſerted in the Philoſophical Tranſactions for 1802, have placed this ſubject in a new light. The exiſtence of native iron, which is ſtill diſputable as an ore, ſeems to have been at length eſtabliſhed on a foundation reconcileable to the acknowledged truths of philoſophy.

Many new ores of metals have alſo been

diſcovered in different countries. Prouſt has announced in the Journal de Phyſique, Pluvioſe, An. x. a native Sulphuret of Manganeſe; and Vauquelin has deſcribed in the Bulletin des Sciences, No. 55, An. x. a Blue Oxide of Iron; and in Van Mons's Journal de Chimie, he has mentioned the diſcovery of Chromate of Iron in abundance, and of a neutral Phoſphate of Iron, in France.

The experiments of Profeſſor Prouſt on Native and Artificial Sulphurets, inſerted in the Journal de Phyſique, liii. 92, are compoſed of a detail of new facts and elucidations on the nature of theſe compounds, which will be read with the moſt lively intereſt.

From the remarks of Thenard, Bulletin des Sciences, No. 77, it will be ſeen, that two ſpecies of acetite of lead exiſt; the proportions of the one are, oxide of lead, 58; acetous acid, 26; water, 16;—and of the other, or new acetite, oxide, 78; acid, 17; water, 5.

In the Philoſophical Tranſactions for 1803, Mr. Smithſon has inſerted an analyſis of ſome calamines, in which he ſhows that they are not, as has been before believed, pure oxides of zinc; but that carbonic acid enters into their compoſition. The electrical calamine, he ſhows to be a combination of oxide of zinc and quartz.

A conſiderable progreſs has been made in the application of chemical knowledge to vegetables, and many intereſting memoirs have been produced in conſequence.

Among theſe, that which is more immediately connected with the preſent work is, that of Profeſſor Prouſt, Journal de Phyſique, An. xi. on the Fecula of Green Plants. In it he refers to the obſervations of Fourcroy, on the inaccuracy of former writers, and appears diſpoſed to accuſe him of miſquotations in ſome inſtances. He alſo draws ſeveral inferences on the nature of this vegetable product which do not accord with the opinions of our author.

Seguin's Inquiries concerning Fermentation, in the Bulletin des Sciences, No. 75; and Thenard's Memoir on the Vinous Fermentation, in the Annales de Chimie, for June laſt, differ conſiderably from the theory of Fourcroy. The former conſiders the preſence of ſaccharine matter as unneceſſary to this proceſs, and the latter is of opinion, that the fermenteſcible cauſe is of an animal nature.

Two new proceſſes for obtaining the pure gallic acid have been publiſhed: one in Van Mons's Journal de Chimie, by Fiedler, directs the precipitation of the extractive matter and tanin by alumine. The other is by Schnaubert, and is inſerted in Tromſdorff's Journal der Pharmacie, vol. ii. 61. His proceſs conſiſts in decompoſing the gallate of lead by ſulphuric acid. He alſo remarks that the cryſtallized gallic acid is alterable by the action of light; and recommends that it be kept in its liquid ſtate.

In Animal Chemiſtry, the inveſtigations and reſearches of experimentaliſts have not been leſs ſucceſsful.

Trouſſet, in a Memoir on Cutaneous Aëriform Tranſpiration, Annales de Chimie, xlv. 73, takes a retroſpect of the inquiries of former phyſiologiſts on this ſubject, and from an analyſis of the gas emitted by the ſkin, concludes, that it is pure nitrogen, without any mixture of carbonic acid gas.

Prouſt, in a letter to Delametherie, Journal de Phyſique, obſerves, that the urée, as examined by Vauquelin and Fourcroy, was not pure, but ſaturated with ammonia. He directs this alkali to be ſeparated by ſulphuric acid, and ſays that it ſtill contains a reſin from which he had not been able to free it.

A Paper read before the Royal Society, in Auguſt 1802, on the Analyſis of a Pulmonary Calculus, by Doctor Crampton, denies the compoſition of theſe concretions, as ſtated by Fourcroy. From his analyſis it appears that the component parts are carbonic acid, 37; lime, 45; albumen and water, 18. At the ſame time he admits the poſſibility of two ſpecies of theſe ſubſtances being formed in the lungs, one of which may be phoſphate of lime.

The chemical nature of the Humours of the Eye, has been very carefully examined by Mr. Chenevix. His obſervations are inſerted in the Philoſophical Tranſactions for 1803. He found the component parts of each of them to be the ſame, but thoſe of the cryſtalline humour differed in their proportions

portions from the other two. They conſiſted of water, albumen, gelatine, and muriate of ſoda, but he could not diſcover either a phoſphate or an earth, as had been formerly ſtated.

Since the publication of this work, a Memoir, by Fourcroy and Vauquelin, has appeared in the Bulletin des Sciences, No. 70, in which they ſhow that the formic acid is a compound of the malic and acetic acids.

In the Annales de Chimie, xxxix. 193, is a Memoir by Thenard, on the Sebacic Acid, in which he contends that the product which had formerly been examined by Chemiſts under that name, was not the peculiar acid of fat, but a foreign acid, which in ſome proceſſes was the acetous acid, and in others the muriatic. He gives directions for obtaining the true ſebacic acid, and deſcribes the peculiar properties of it with accuracy. He promiſes further details when he ſhall have operated on other facts: the only one from which he obtained this acid was hog's-lard.

Vauquelin, in a letter to Van Mons, inſerted in his Journal, i. 218, ſays, the ſame

Chemiſt had juſt finiſhed an examination of the zoonic acid, which he found to be acetous acid combined with a peculiar animal matter.

Several new Foſſils have alſo been ſubjected to chemical examination.

Tromſdorff, Crell's Chem. Annalen, 1801, part vi. 1. has analyſed one from Greenland, which he names Compact Hyacinth. Its component parts are ſilex, 50; alumine, 28; oxide of iron, 6; zircone, 10; loſs, 6.

A ſiliceous ſtone, from Egypt, called Heliotropium, has been examined by Mr. Accum, Journal of Natural Philoſophy, &c. conſiſting of ſilex, 73; alumine, 4.05; oxide of iron, 5.85; lime, 11.3; water, 4.8; loſs, 1.

In the Memoirs of the Royal Academy of Berlin, for 1803, p. 243, is an eſſay by Klaproth, on the Analyſis of a Foſſil, which he names Natrolite, from the quantity of ſoda it contains. It yielded him ſiliceous earth, 48; alumine, 24.25; oxide of iron, 1.75; ſoda, 16.50; water 9.

The arts and manufactures have derived

material advantages from the rapid progreſs of chemical inquiry.

In the Journal de Phyſique, Vendemiaire, An. xi. the younger Darcet has given a new proceſs of Refining, in which time, labour, expence, and loſs, are ſaved. He proceeds in the former method as far as the ſecond ſolution in nitric acid, inſtead of which he directs the gold to be boiled with ſulphuric acid, in as ſmall a veſſel as poſſible for an hour. He then decants the acid and waſhes the gold, until no more precipitate is obtained from the water by muriatic acid or alkalies. The gold will then be pure.

Brongniart, Journal des Mines, No. 67, has given a number of intereſting facts, from his own experience, on the production of colours from metallic oxides in the manufacture of porcelain. The proceſſes, which have been kept a ſecret in the manufactory of Sevres, are diſcloſed in his memoir, and a very minute detail is given of the ſpecies of oxides and fluxes, calculated to produce brilliant and durable colours on the three grounds, viz. enamel, porcelain, and glaſs.

Mr. Davy's experiments on Aſtringent

Vegetables, and on the operation of Tanning, in the Philoſophical Tranſactions for 1803, yield a conſiderable fund of information. He infers, from the reſearches he has made, that leather abſorbs extractive matter as well as tanin, and that the qualities of the leather are affected by it, ſo as to render it an eſſential ingredient in the operation, and that the various ſolvents which have been propoſed to expedite the proceſs are injurious.

Berthollet has publiſhed in the Journal de L'Ecole Polytechnique, iv. 319, a method of giving the Appearance of Cotton to Hemp or Flax; in which he aſſerts that the product of the coarſeſt hemp becomes equal in texture and appearance to cotton, and propoſes to make even the refuſe of rope-walks into a ſubſtance valuable in the arts.

Curaudau's Proceſs for fabricating Alum artificially, with a profit of from 17 to 25 per cent. more than by the old proceſſes, is inſerted in the Annales de Chimie, An. ix. No. 137. He directs 100 parts of clay, and 5 of common ſalt, to be kneaded with water, and formed into loaves, which are to be calcined in a reverberatory furnace. The loaves are then to be reduced to powder, and one-fourth by weight of ſulphuric acid poured over them at intervals to diſengage the muriatic acid. The operation is then continued by adding water at intervals, in quantities equal to the acid, until about eight or ten times as much water as acid has been uſed. The fluid is next permitted to ſettle, and the clear lye is drawn off into leaden veſſels. A quantity of water equal to that drawn off, is then poured on the reſiduum, which is afterwards drawn off and added to the firſt. Laſtly, a ſolution of pot-aſh, in which the alkali is equal to one-fourth of the weight of the acid, is added, and the whole is agitated. As the liquor cools, cryſtals of alum are formed, which will amount to three times the weight of the acid employed. The alum is afterwards refined by diſſolving it in the ſmalleſt poſſible quantity of boiling water. Sulphate of pot-aſh may be uſed inſtead of the pure alkali, but in that caſe the quantity muſt be double. The mother water ſtill contains alum, with ſulphate of iron much oxided, and is recommended to be uſed in the fabrication of Pruſſian blue.

I ſhall conclude this Preface by acquainting the Reader, for his convenience, that moſt of the excellent works I have here referred to, in their original publications, are alſo to be met with, either tranſlated, copied, or abridged, in my Journal. By giving this notice, I feel no ſolicitude of any imputation of perſonal motives in thus recommending my own work. If I have done my duty in ſelecting, this muſt naturally be the caſe, and the Reader will, I hope, be accommodated by being reminded of it.

W. N.

Soho Square, March 1, 1804.

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PRELIMINARY DISCOURSE.

THERE is a progreſſive advancement in the intellectual labours of man, of which philoſophy is calculated to mark the different epochas, and which enables us to form a compariſon between each ſucceſſive age with regard to its advances in the powers of reaſon. The hiſtorians of ſcience uſually direct their inquiries to aſcertain theſe epochas, and the annals of the different branches of knowledge all preſent them, with features more or leſs worthy of remark.

Chemiſtry alone ſeems to form an exception: it is diſtinguiſhed perhaps much more from all the other ſciences by its origin and by the epochas of its progreſs, than by its object, its proceſſes or its reſults. It is perhaps the only ſcience which is intirely of modern creation, of which no trace is to be found in ancient times, and which does not exhibit in its periods that ſlow progreſſion, that ſucceſſive increaſe which the obſerver may diſcover in every other branch of human knowledge. It is in vain that, by confounding certain rudiments of the chemical arts with chemiſtry itſelf, in which the chimerical art of fabricating gold is every where exhibited as the only and the moſt important of its labours, the firſt hiſtorians of that ſcience have placed its commencement in fabulous times, more early than even the heroic ages, and traced its exiſtence to epochas little diſtant from thoſe when the delirious imagination of the firſt poets, and the pious fictions of the authors of certain religious chronicles, have dared to ſuſpend the eternal march of nature, and ſet limits to its exiſtence by fixing the creation of the world.

All that has been aſſerted concerning the ancient origin of chemiſtry, concerning thoſe men who firſt worked the metals, cut and poliſhed the hard ſtones, fuſed the ſands or diſſolved and cryſtallized the ſalts, muſt evidently appear to an exact and ſevere inquirer to be no more than a vain and ridiculous pretenſion; ſimilar to that by which the elements of geometry might be traced in the rude works of the ſavage who takes the fragments of rocks, and gives them forms nearly regular, to adapt to his immediate wants. Though the remains of monuments, majeſtic by their aſtoniſhing dimenſions, ſtill exiſt in ſpite of the outrages of time and the inſults of the warlike hords of every age, and atteſt to the obſerver that the ancient inhabitants of Egypt, of Syria, of Paleſtine, like thoſe of certain parts of India, poſſeſſed the arts which we at preſent name chemical; though the remains of their temples, of their pyramids, of their canals, of their ſculptures, are ſufficient to prove that theſe people fuſed, diſſolved and alloyed the metals, that they fabricated glaſſes, enamels and cements, of durable and varied colours; nothing announces, notwithſtanding the magnitude and number of operations which theſe remains ſuppoſe, that they required the exiſtence of chemiſtry among theſe nations already ſo induſtrious and ſo enlightened. There are opinions which place the origin of this ſcience in the firſt ages of the world, and conſequently among the learned people of antiquity of which hiſtory compoſes her firſt pages; but this opinion may be claſſed with all the exaggerated and truly ſuperſtitious notions which have ſucceeded the pretended occult ſciences, divination, oracles, apparitions, ſpirits, aſtrology, the divination by numbers magic and numerous other follies, which are, in the eyes of the philoſopher, noxious productions of the human mind; as the poiſon of ſtramonium, the fungus or of the viper, are products of nature no leſs than the roſe, corn, and the uſeful animals.

The love of the marvellous, the deſire too frequently reduced into a ſyſtem of finding nothing new, and of placing the preſent age below every other with the prejudice ſo common, though ſo unreaſonable, of meaſuring the grandeur and importance of an occupation by its antiquity and its long uninterrupted exiſtence, have thus contributed to place the firſt dawn of chemical ſcience in times where tradition, monuments and hiſtory are equally ſilent.

Certain enthuſiaſtic writers of the fifteenth and ſixteenth centuries, had ſcarcely announced this opinion concerning the ancient exiſtence of chemiſtry, when it was quickly repeated in every work, returned as it were by all the literary echoes, and was received like an axiomatic truth. There does not exiſt perhaps a ſingle treatiſe on chemiſtry, of which the firſt lines are not marked by this aſſertion.

But if we examine with courage and without prejudice all the proofs which have been united to eſtabliſh the exiſtence of chemiſtry among the Egyptians, after having carried back its origin to the firſt ages of the world and to the firſt labours in which men employed fire as an agent, it will ſoon be diſcovered that they are merely deduced from products employed in their various conſtructions; and that though they may all announce the exiſtence of arts or proceſſes of fabrication more or leſs advanced, yet they diſplay nothing which has the appearance of general inference deduced from a compariſon of theſe arts,—nothing which depends on a connected ſeries of argument or induction,—nothing in a word which can give a ſingle idea of true ſcience; ſtill however their monuments, their ceremonies, their ſolemnities, their worſhip, their political and their civil uſages, all indicate that this people then poſſeſſed a knowledge of aſtronomy, geometry, general phyſics, natural hiſtory and medicine. The revolutions of the planets were painted and deſcribed on the walls and ceilings of their temples; mechanical ſcience afforded them the means of tranſporting immenſe burthens to conſiderable diſtances and heights; geometry guided them in the conſtruction of aqueducts, and the canals of irrigation; the nilometer, conſtructed on an accurate knowledge of machines and of levels, was elevated in the midſt of the waters to announce what might be expected in the productions of the ſoil to which the river gave fertility; the culture of the ground was varied, regular, and indicated the early occupation of that ſoil; medicine was practiſed by the prieſts; aſtronomy, geometry and mechanics had made a progreſs which ſuppoſed obſervations already numerous and the eſtabliſhment of ſcientific principles. Though no ſenſible traces now remain of their having eſtabliſhed diviſions and methodical claſſifications in the productions of nature, the care which the Egyptians had of certain plants and animals, the myſtic or emblematical employment which they made of them in their religion, ſhew at leaſt that they paid a particular attention to them, and that they ſtudied their manners and their properties. But nothing of this kind exiſts with regard to chemiſtry:

there was then no real connexion between the arts and fabrications which we now denominate chemical and chemiſtry itſelf. No one had yet buſied himſelf to deduce general notions from the compariſon of theſe arts, or in eſtabliſhing thoſe connexions between their products and their reſults which did not form an outline of ſcientific theory, till a long ſeries of ages after the almoſt total deſtruction of that ancient people. The Egyptian chemiſtry has no exiſtence but in the imagination of hiſtorians, and it is a real error to attempt to diſcover its origin there.

Among the emigrations of this powerful nation, in the colonies which founded that ingenious and poliſhed nation, which placed in the ſucceſſion of ages to ſerve as a model to every future time and country in the arts of imagination and of taſte;—among thoſe Grecians who, owing their firſt knowledge and origin to Egypt, have aggrandized thoſe arts, and given to them thoſe amiable forms which will ever adorn them;—among theſe we ſeek in vain for veſtiges of the exiſtence of chemiſtry. The Greek philoſophers poſſeſſed all the ſciences, which they have claſſed methodically and reduced into ſyſtem; they taught them in their public ſchools, where the youth of greateſt hope, or men of all countries who wiſhed to cultivate their reaſon, came to obtain ſolid inſtruction. The wiſe Socrates; Plato, whoſe vaſt knowledge procured him the appellation of divine;

vine; Ariſtotle whoſe genius, aided by the extenſive means of Philip and of Alexander, have ever appeared to deſignate him as the chief of writers on the natural ſciences; all the other philoſophers who, by the generality of their ſtudies, the grandeur of their meditations and the profundity of their views, have embraced every ſcience; morals, politics, legiſlation, logic, phyſics, the hiſtory of nature and of man; thoſe firſt encyclopediſts who, deprived of the hereafter unperiſhable reſource of printing, ſupplied its want, as far as was in their power, by public lectures, have left us without information concerning the alterations and the mutual changes produced in one body by another;—the phenomena of chemiſtry. The energy of their minds was not ſufficient to deduce the intimate action of the different particles of bodies on each other; the art of queſtioning nature by experiment cannot be ſtated as part of their philoſophy. It dates much later: and ſome uncertain lights, the mere products of imagination, conſtituted in thoſe celebrated ages the only part which reſembles what we now call chemiſtry. The ideas of Epicurus, of Thales, of Anaximenes and of Anaximander, as well as thoſe of Plato and Ariſtotle, concerning the principles of bodies, the elements, fire, air and water, can only be reckoned among ingenious romances no leſs foreign to chemical ſcience, than the fictions concerning fabulous perſonages are foreign to hiſtory. Let Democritus be repreſented, by the powers of fiction, as ſhutting himſelf up in a garden near Abdera, to extract the juices of plants; where, in order to meditate with more vigor, and to avoid all diſtraction, he is ſaid to have voluntarily deprived himſelf of ſight: let this apocryphal trait of Grecian hiſtory be rendered leſs improbable, by attributing the loſs of his ſight to long obſervations on light and objects too luminous, inſtead of ſtating it to be produced by the reflection of the burning rays of the ſun, returned by a ſurface of poliſhed braſs: whatever colour may be given to this pretended fact, cool reaſon will find no proof, nor even probability that this philoſopher did cultivate chemiſtry. No fact whatever can demonſtrate that this ſcience exiſted in Greece, while every thing atteſts the high degree to which geometry, aſtronomy, medicine, politics, natural hiſtory and muſic had there arrived. Never did the Lyceum, the Academy or the Portico adopt any notion, or any chemical fact among the ſciences which were there taught.

Though the greater part of theſe ſciences paſſed from the Greeks to the Romans, who took them for their maſters in every department, and though ſome of them, particularly aſtronomy, natural hiſtory and medicine, made remarkable progreſs among them; in ſpite of the preference which this people of kings and warriors gave to eloquence and to poetry, it is ſtill impoſſible to find in ancient Italy the cultivation and conſequently the origin of chemiſtry. There is reaſon to believe that certain chemical arts which at that time exiſted, were exerciſed at Rome by Grecian artiſts, who were invited thither as well as ſculptors, painters, architects, muſicians, and even the maſters of eloquence, of poetry and of philoſophy. The pretended diſcovery of malleable glaſs preſented to Nero or Tiberius, would at moſt prove the advanced ſtate of an art, but by no means the exiſtence of true chemiſtry among the Romans.

It was not till thoſe ages when the Arabians cultivated the uſeful ſciences, that ſome firſt very evident traces of chemiſtry began to be ſeen. The multiplicity of medicines which their phyſicians introduced into practice, the great number of compoſitions which they invented, the complicated preparations which they cauſed them to undergo to adapt them to the diſeaſes they wiſhed to combat: ſuch was the true origin of that ſcience. By treating plants and animals by fire and water, in diſtillatory veſſels, they ſeparated from them different volatile ſubſtances, and obtained from them products, which were conſtant in ſimilar circumſtances, and varied when the circumſtances were alſo changed.

After this period, in which ſugar, honey, the gums, manna and the reſinous juices began to be employed in medicine as vehicles or recipients, or as particular remedies, the formulæ of their mixture, of their decompoſition or of their combination, always more and more varied, afforded a thouſand opportunities of obſerving and deſcribing the action which bodies are capable of producing on each other.

In the ſixteenth century ſome men of genius aroſe, who diſcovered in the art of preparing medicines a ſeries of general principles of which they attempted to form a body of doctrine. Under this art, in itſelf eſſentially chemical and very general in its proceſſes, an arrangement was ſpeedily made of all thoſe other arts which conſiſt in varying by mixture and by the action of heat, of air and of water, the intimate properties of the different ſubſtances which are ſubmitted to theſe proceſſes. Compariſons were made between the medical formulæ and the proceſſes for treating, fuſing, alloying and oxiding the metals, their combinations with ſulphur, the extraction of ſalts, their decompoſition and the acid ſpirits of various ſtrengths which are obtained from them; the vitrifications, the preparation of colours, of dyes and of perfumes, arts which were all in different degrees laid under contribution for the preparation of medical compounds. This is the true ſource of the intimate connexion of chemiſtry and pharmacy, of the common fate of the two occupations, and the union and even the confuſion of the practice of each in the ſame laboratories and by the ſame operators.

This approximation, this kind of identity would have infallibly continued to exiſt, and the application of chemiſtry, completely pharmaceutic would have been irrevocably fixed, if an event of great importance in the hiſtory of natural ſcience, one of thoſe circumſtances which, by deeply influencing the progreſs of the human mind, effect a complete renovation in its productions and in its diſcoveries, had not intervened. Without this event, whatever the ableſt men could have done would have been limited to connect with chemico-pharmaceutic facts all the prejudices and impoſitions of the philoſophy of the ancients, and thus to give a ſcientific form, and at leaſt a ſyſtematic appearance to the principles of which reſults were connected.

After the long ſervitude of ages, after the heavy yoke of the peripatetic doctrine and of the ill-conceived formulæ of Ariſtotle, under which the ſchools were enſlaved and the ſpirits of men held captive, at length appeared the happy days prepared by Deſcartes and Galileo, —when thought and genius, diſengaged from their fetters, ruſhed on to new conqueſts. Inſtead of darkening by commentaries the frequently disfigured works of the ancients; inſtead of giving ſervile belief to propoſitions which acquired nothing from the ages through which they had paſſed but the habitude of adoption, philoſophers have dared to direct their regards with becoming humility and diffidence to the proſpect of nature, to interrogate her phenomena and penetrate the ſecret laws of things. Obſervation has taken place of blind and confident credulity. The grand idea of cauſing the natural forces to act between bodies brought together by art, and to determine their exiſtence, direction and energy, has ariſen as if from nothing; the experimental art appeared in the world as a new creation; and this ſtar, deſtined for ever to illuminate a vaſt horizon, irradiated a vivid light, hitherto unknown to the ſciences. On a ſudden natural philoſophy, which before this time had been only the romance of nature, became its faithful interpreter. Supplied with ingenious machines and inſtruments, it added this new power to the too limited efforts of genius; its forces were redoubled, as the lever added to the muſcles of man and of animals multiplies their efforts. A new order of things, a new world more precious a thouſand times than that for which the ancient world is indebted to the diſcovery of Chriſtopher Columbus, was preſented to philoſophy. The Boyles, the Newtons, the Mayows, the Hookes, the Stahls, the Hales and the Boerhaaves, then travelled from diſcovery to diſcovery; and far from deſtroying men, from depopulating vaſt continents, and kindling in the hearts of kings, of conquerors and of adventurers the thirſt for gold, for riches and for luxury, as the diſcovery of America had done, this experimental world acquired the mildeſt conqueſts, multiplied the enjoyments of nations, enriched all ſociety, and cauſed every branch of natural philoſophy to advance with the moſt rapid progreſs.

Chemiſtry, diſpoſed by its nature and its pretenſions to a great variability, received a part of this new movement; it was no longer confined to the laboratories of pharmacy; it was no longer limited to the preparation of medicines. Tranſported into the new laboratories of natural philoſophy, it approximated itſelf to this renovated ſcience, and united with it by an indiſſoluble connexion, it became one of its integrant parts; and though always diſtinguiſhed from it by the ſubjects which it treats, by the means it employs, and by the purpoſe to which it is directed, as well as the reſults it obtains, yet its diſtinct exiſtence was well aſcertained; and at length it acquired a method and views ſo general in compariſon with the confined ſphere to which it had before been circumſcribed till that glorious epoch, that the philoſopher, in inquiring into its true place in the methodical table of the ſciences, aſſigned its place, under the name of *particular phyſics,* immediately after the leading title of *general phyſics.*

The greateſt part of a century of uninterrupted experiments and reſearches among the moſt enlightened people of Europe, concerning the chemical properties of bodies, after chemiſtry had been ſeparated from the pharmaceutic art which for ſo long a time retained it captive, had nevertheleſs proclaimed it almoſt in vain as the ſcience of nature. It was rather by a ſort of inſtinct or of divination than by a decided reſult. In vain did its aſſociation with experimental philoſophy and its Newtonianiſm elevate it to an height, from which it has thrown light on the production and alterations of minerals, on the phenomena of vegetable and animal life and on the ſciences which ſtudied its appearances and changes, as well as on the manufactures which modify in a thouſand manners its products. Notwithſtanding almoſt a century of independent exiſtence, its reſults poſſeſſed little accuracy, its data were too incomplete, its means too limited, its wants and its uncertainties too numerous, and its progreſs in the road of experiment too uncertain to afford to the philoſophy of nature the whole that was expected from it. Aſtoniſhed at the number and at the magnitude of the obſtacles which oppoſed their advances, chemiſts were almoſt diſcouraged, and deſpaired, even thirty years ago, of ever being able to diſcover the cauſe and the relation of the natural phenomena which were become the ſubject of their inquiries and the aim of their meditations. Struck myſelf, in my firſt chemical ſtudies, by this kind of diſcouragement, with what ſentiment of profound admiration for the modern diſcoveries do I now recall the philoſophic complaints of my firſt maſters, Macquer, Roux and Bucquet, concerning the impoſſibility of diſcovering the origin of the mineralization of waters, of the ſpontaneous alterations of foſſils, the cauſe of fermentation, and the intimate changes of many bodies, of the phenomena of vegetation, of the motions and modifications of animal fluids, and of a number of the other operations of nature, which they then believed to be covered by a veil impenetrable to man!

In the midſt of theſe immenſe difficulties, from the depth of fruitleſs and diſcouraging efforts, what a glorious and unexpected ſcene preſents itſelf to my recollection! An event, of an importance equal to that of the diſcovery of the experimental art, for the progreſs of the human mind, now changes the face of chemiſtry, opens to a new career, and elevates it in a few years beyond the utmoſt hopes of philoſophers. In 1757, a light being, unknown till that time by chemiſts, inviſible to them, and incoercible by the methods and the machines which they employed; a fluid which had a thouſand times preſented itſelf in their experiments, but without giving them till this time the leaſt notion of its preſence, by the elaſtic form which it aſſumed and which concealed it under the appearance of air; a body performing an extenſive part in the moſt important phenomena of chemiſtry, was diſcovered and as it were extracted from that non-exiſtence where it had remained for philoſophers, by the illuſtrious Profeſſor Black of Edinburgh. Simply obſerved thirty years before by Hales, but conſidered as an air capable of being fixed, it was ſhewn by Black to be the cauſe of many phenomena yet unexplained, and was carefully diſtinguiſhed from common air. It then became, by its remarkable properties, the ſubject of a thouſand new reſearches. Three luſtra had ſcarcely elapſed ſince the diſcovery of Black, before this new being became better known than the greater number of the ancient bodies; its hiſtory is already more complete than theirs; its influence on the knowledge of chemical phenomena is already immenſe. It has deſtroyed a great many ancient opinions which were groſsly erroneous; it has emitted a thouſand new lights; it explains a number of obſcure facts; and in particular it has conducted to the knowledge of many other beings which, ſimilar to itſelf by their rare and gaſeous form, having been concealed under that form from chemiſts, and being therefore wanting to the explanation of experiments which had till then been made, as well as to the calculation of the products, have left the ſcience in that vague and uncertain ſtate of which philoſophers have complained, and which with ſome juſtice they ſeemed to attribute to the jealous concealment of nature. Then, and under the auſpices of theſe diſcoveries concerning the elaſtic fluids, the compoſition of air and its influence on the phenomena of nature and of art, it was that Lavoiſier ſaw that all the ancient data of chemiſtry were fettered with errors originating in our ignorance of gaſeous matters, which were always loſt to chemiſts. He perceived that it was neceſſary to give a new form to its whole theory more ſuitable to truth, as well as to new model its inſtruments and apparatus. Genius elevated and truly creative, courage to ſurmount all the obſtacles which were ſure to be met with, ſkill to perform the moſt delicate experiments which had yet been made, preciſion and delicacy in the obſervation of phenomena, ſevere and geometrical reaſoning in the compariſon of reſults, views no leſs profound than extended; —theſe were the qualities poſſeſſed by Lavoiſier, a man fully equal to operate the reform which he meditated, and to produce a grand revolution in the ſcience. He undertook and completed it by the uninterrupted labour of fifteen years. He repeated the principal experiments of chemiſtry with new inſtruments, and by proceſſes adapted to enable him more eſpecially to diſcover the action and the influence of fluidifiable bodies, which ſo long had eluded the ſight as well as the diſcernment of philoſophers. The doubts of philoſophy during ſome years ſuſpended the fate of this grand reform in uncertainty; the new propoſitions of Lavoiſier were examined with deliberation, weighed with prudence and proved by mature and long reflection. It was adopted at laſt by the French chemiſts, who ſoon became his co-operators and inſtituted a new doctrine which has been denominated the *Pneumatic Chemiſtry*, on account of its origin in the knowledge of air and of fluids which reſemble it in their form. The author of a revolution ſo great and ſo fortunate for the progreſs of the human mind was entitled to the reſpect and admiration of his contemporaries, and will ſurely obtain that of poſterity. He deſerved an altar, but the crimes of men devoted him to the ſcaffold. His fate was that of Socrates, of Phocion, and ſo many other victims of their virtue and of their love for truth.

A witneſs to this renovation of the ſcience, to which I have contributed, during twenty-ſix years, as far as my feeble efforts have permitted me, I have beheld chemiſtry enriched by a number of new facts and capital diſcoveries, proceed at length with an aſſured ſtep in the explanation of the moſt enlarged phenomena of nature. I have beheld it, no longer confined to the mere laboratories of the arts, extend its rapid flight to the ſublimeſt heights of philoſophy; and purſuing paths till then unknown, extend its light to operations of nature formerly regarded as impenetrable myſteries. Placed for ever in this elevated rank, rich with all its new conqueſts, with ſcarcely any further obſtacles or difficulties to be apprehended in its inquiries, it is become at the ſame time the ſcience moſt adapted to the ſublime ſpeculations of philoſophy, and the moſt uſeful in advancing all the operations of the arts. Exact in its proceſſes, ſure in its reſults, varied in its operations, abounding with reſources from its inſtruments, its apparatus and its modern manipulations, without limit in its applications and its views, ſevere and geometrical in its reaſonings, there is ſcarcely any human occupation which it does not enlighten, and upon the perfection of which it may not have a great influence. This ſcience attends the mineralogiſt and the geologiſt in the boſom of the earth and on the ſummits of the mountains, to develop the nature, the compoſition, the changes, frequently even the origin as well as the future fate of the different beds of the globe and of the foſſils of which they are formed. Occupied in the examination of vegetable productions and of the periods of the life of plants, from the firſt germination to the formation of the ligneous ſubſtance, it opens to the botaniſt and the agriculturiſt a treaſure of diſcoveries and of proſpects adapted to explain the ſecret of vegetation. Applied as it has been with unparalleled ſucceſs, eſpecially during the laſt fifteen years, to the analyſis of liquid and ſolid animal matters, it at laſt affords the hope, ſo many ages given up, of conceiving the phenomena and even the ſources of life, by the happy explanations which it has began to give concerning numerous points of phyſiology.—It throws a new light on all the great changes of the atmoſphere, on the fluids which traverſe it, which become diſſolved or are precipitated and perpetually modify their properties and the influence upon all the beings which people the earth.—

earth.—From theſe grand occupations, this comprehenſive ſcience deſcends to every reſidence of the arts, where it changes the form and the qualities of the productions of nature to appropriate them in a thouſand manners to our wants; it teaches us to chooſe the earths proper for pottery, for vitrification, cements, and mortars, the ſtones uſeful in different buildings, for cutting, poliſhing, and for ornament; it explains the multiplied ſtates of the metals in their earthy beds; it teaches the art of extracting them from their ores, of fuſing, of purifying, of alloying, of diſſolving, of oxiding, and of cauſing them to aſſume durable colours.—Among the numerous means of preparing the different products of vegetables for our dwellings, our machines, our clothing, our food, and our medicine, it is chemiſtry alone which directs, varies, improves, and even creates at pleaſure.—Its proceſſes, applied to the ſkins of animals of every kind as well as to the different liquids which they afford, appear to extract, even from the boſom of death, products deſtined to ſupport, to recall, and to embelliſh life.—Thus it is that no object can eſcape this happy ſcience; its influence is no leſs extenſive in ſociety than the numerous facts it includes, and the opportunities of applying its precepts are multiplied. As it beſtows enjoyment to every claſs of individuals; as it is of abſolute neceſſity in the greater number of profeſſions; as it is formed to illuminate almoſt every ſpecies of human knowledge; what ſcience can be better entitled to be called the univerſal ſcience?

This truth is already ſo extenſively eſtabliſhed, that the ſtudy of chemiſtry has become much more general than it ever has been, even during the laſt twenty years of the laſt century. Every man who receives a liberal education, at preſent conſiders chemiſtry as one of the moſt indiſpenſable objects of his ſtudy. Diſengaged from the chimerical and ridiculous notions, which ſo long repreſſed every candid inquirer, liberated at length from the prejudice which for ſo many years conſidered it only as a branch of medicine, and confounded it with pharmacy, it is now cultivated by almoſt every claſs of ſociety. In the numerous ſchools of inſtruction which have been erected throughout the Republic, the philoſopher, the legiſlator, the miniſter, the naturaliſt, the phyſician, and the cultivator, are aſſociated with the manufacturer, the workman, the painter, and the dyer. The civil and military engineer, the artilleriſt, and the ſeaman, there attend together to the ſame maſters who inſtruct the practiſer of pharmacy, the diſtiller, and the perfumer. In a word, all deſcriptions of men there obtain accurate and uſeful notions of their different kinds of employment, becauſe it is equally impoſſible for any of them to neglect that ſcience which alone can enable them to appreciate the mutual action of one body on another, the changes which they undergo by contact, the modifications of form, of taſte, of colour, of ſmell, and of conſiſtence which they aſſume by combination or decompoſition, the durability or changes of their natural or acquired properties, the effects to which they are ſubjected by the laws of nature or the efforts of art, and thoſe which they produce on the organs of men and animals.

Penetrated by theſe truths concerning the great advantages and the inexhauſtible reſources which chemiſtry affords in every human occupation, I have conceived and executed, as well as circumſtances could allow, the project of introducing the ſtudy of this ſcience into the national ſcheme of education. The organization of the central ſchools in the departments of the French republic preſented an opportunity too favourable for this purpoſe, for me to let it paſs without advantage to my fellow citizens. Chemiſtry, combined with phyſics, has become one of the principal branches of that excellent eſtabliſhment. Though the number of men ſufficiently ſkilled in that ſcience to teach its principles to the youth of France has not yet proved equal to that of the chairs inſtituted by the law of the 3d Brumaire, of the 3d year, this defect will be but momentary. Every day it becomes leſs; and, in a few years, theſe numerous lights of ſolid inſtruction will ſhine upon every point of that happy ſoil which will again collect its influence. When we reflect on the benefits which this immenſe maſs of information diffuſed over France muſt produce to every part of the public economy; on the means, the development, and the force which they will give to all the products of induſtry; when we conſider how many truths either totally unknown or ſtill little known, they muſt render familiar and domeſtic, the number of ameliorations which they will afford in our furnaces, our workſhops, and our manufactories; the maſs of errors which they will correct and that of the prejudices which they will diſpel; we may then form ſomé notion of the great benefits the French people will receive from theſe new eſtabliſhments. Celebrated facts, which will occupy a ſtriking place in the hiſtory of nations, have already ſhewn in the moſt effectual and permanent manner the powers of chemiſtry to advance the public economy, and inſure the ſafety and the defence of nations. The annals of the French revolution will tell to the world, how much the war of liberty is indebted to the inventions and to the reſources of chemiſtry. France, preſſed by powerful and numerous enemies, blockaded at ſea by their coloſſal fleets, deprived of the products which commerce afforded her in ordinary times, was deſtitute of ſaltpetre, of copper, of ſteel, of mercury, of ſulphur, of leather, and of a number of other objects more or leſs neceſſary to the wants and the ſupport of its inhabitants. The arms of her numerous and valiant defenders could not effect this, and her ſoldiers themſelves were deſtitute of arms to render them formidable to her enemies. Her ſoil, ſo rich in productions, did not ſeem calculated to afford what her commercial induſtry had till then obtained in foreign countries. Without the genius of chemical ſcience, ſhe would have been threatened with an abſolute want of the means of defence. An active adminiſtration accuſtomed to overcome every reſiſtance, becauſe it felt all the power of the French people, and becauſe it knew how to employ the whole of their force, conceived the hope of finding in chemiſtry what the ordinary courſe of manufactories could not furniſh, and what interrupted commerce refuſed. It called together the moſt enlightened chemiſts, united them and explained to them its preſſing and extenſive wants, the confidence which it placed in their knowledge, and the aſſiſtance it demanded from them. Its expectation was not diſappointed: its hopes were realized even beyond the point to which they were directed! We have ſeen all France informed by this aſſembly of learned men, of the immenſe quantity of ſaltpetre which nature had depoſited in her boſom; we have ſeen the whole ſtate converted into ſaltpetre works, all the citizens occupied and emulating each other in the ſearch and extraction of this ſalt. Speedily the national manufactories, the arſenals, the ports, the ſtrong places, and the camps, became ſo fully ſupplied by this immenſe formation, beyond every meaſure and proportion till then known, that after ſeven years of dreadful war this vaſt proviſion is ſtill far from being exhauſted, and the movement communicated by this vaſt enterpriſe may indeed be retarded, but can never be entirely ſtopped. This famous inſtance never will be loſt. Chemiſtry has proved that after ſome years of repoſe, the earth of cow-houſes, of aviaries, of ſtables, of cellars, of caves, and of almoſt all the places inhabited by or ſerving as receptacles for ſtoring animal or vegetable ſubſtances, becomes again charged with ſaltpetre, and that a new extraction of that ſalt made with activity ſimilar to that of the former, and with more regularity and method than that could be in the difficult times in which it took place, will again afford a greater quantity of that ſalt than was at firſt obtained. Here then is an inexhauſtible ſupply diſcovered by chemiſtry of a ſubſtance moſt uſeful to the national defence, and of the higheſt advantage to a number of the works and manufactories. The ſame men taught the method of purifying this natural product in a few hours, inſtead of more than a month which it formerly required, and by that means to render it proper for the compoſition of gunpowder, of which the fabrication has become at once more ſpeedy and leſs dangerous. Is it neceſſary to recall what they have done at the ſame period, to remove the ſame diſtreſs, in the caſting of artillery, the refining and extracting pure copper from bell-metal, and converting it into coin, in the fabrication of ſteel, of muſquets, of ſabres, and of all the arms into the compoſition of which iron enters under that form or in the ſtate of ſteel? Need I ſpeak of the new reſources which they have offered, and the new arts which chemiſtry has created for the quick tanning of ſkins, the compoſition of ſoap, the eſtabliſhment of aeroſtatic balloons calculated to direct the march of our armies; the formation of new weights and meaſures; the preparation of artificial crayons; for the bleaching and re-manufacturing of printed paper; for the proceſſes ſo ingenious and ſo delicate for the fabrication of aſſignats? All theſe teſtimonials, all theſe monuments, raiſed at once among a great people, and which have ſignalized the acquiſition of its rights as well as ſerved to eſtabliſh its liberty on an eternal foundation, will for ever remain among poliſhed nations as imperiſhable proofs of bleſſings which the cultivation and improvement of chemiſtry are calculated to extend to mankind.

It is to France that the renovation, the complete reſtoration, and the perfection of this beautiful ſcience are due; and as it was juſt that ſhe ſhould receive the advantages of this ſcience on a grand and important occaſion when her exiſtence and ſupport were at ſtake, it is no leſs natural that ſhe ſhould behold within her own limits the moſt extenſive eſtabliſhments deſtined to augment the progreſs and extend the powers of chemiſtry.

Such is the nature of the work which I now publiſh under the title of a "Syſtem of Chemical Knowledge, and its Applications to the Phenomena of Nature and of Art." After having ſucceſſively given to the public different elementary works of chemiſtry, under forms varied and appropriated to the end which I propoſed to myſelf in each, all of which were merely deſigned to exhibit the firſt principles of the ſcience,—I have now undertaken to collect all its truths, to combine the whole of them into a more complete and more ample treatiſe than any which has hitherto been formed, and more eſpecially to diſpoſe them after a particular method, in a new order of which the experience of many years of public and private inſtruction has ſhewn me all the advantages. I have been deſirous if not to collect all the known facts of chemiſtry, at leaſt to unite many more than are found in any treatiſe which has yet been publiſhed. This appears to me more particularly neceſſary from the actual ſtate of modern diſcoveries of which no work contains any conſiderable part.

The "Philoſophy of Chemiſtry" which I publiſhed ſome years ago, and which has been received by a diſcriminating public with a degree of indulgence and favour I never dared to hope from the work itſelf, though its form and its progreſs did not appear to me without ſome value for the information of the actual ſtate of the ſcience; the Philoſophy of Chemiſtry

miſtry was particularly directed to aſcertain the opinions of men of ſcience, concerning the general method of explaining the firſt truths of chemiſtry, which I there ſketched. Satisfied with the impreſſion which it had produced among the cultivators of this ſcience, and conſequently with the trial to which this firſt work was directed, I purpoſed to follow a ſimilar method in the detailed expoſition of chemical facts. I have been deſirous of preſcribing to the ſtudy of the ſcience in its utmoſt extent, the ſame courſe which I have already followed in announcing its firſt principles. Though I have not pretended to exhauſt all the facts, the experiments, the phenomena, and the reſults of chemiſtry, an object perhaps above the powers of any individual, however induſtrious or enlightened; I have, at leaſt, endeavoured to collect the greater part, and to preſent an entire ſtructure ſo complete as to leave little more to be deſired.

No work, among thoſe which have fallen under my obſervation, has been formed with the ſame views or arranged on the ſame plan. There is not any work in which an accurate and methodical ſketch of the new diſcoveries has been preſented, or their connexion and their relations can be ſeen. I cannot even with propriety give the name of *Elements* to this work, after thoſe which I have publiſhed under title, and which are entirely different. Facts which far exceed in number what is neceſſary to conſtitute the ſimple elements of a ſcience; a new method ſingularly different from that which directed me in compoſing thoſe works; a much more extended plan in their explanation; and numerous explanations which would have been miſplaced in elementary treatiſes: theſe conſtitute the principal differences between the two kinds of works.

Indeed, if we conſider this work with regard to the objects it comprehends and the purpoſe to which it is directed, namely, of explaining the phenomena of nature and of art; if the diſtance be meaſured which ſtill ſeparates it from that which natural philoſophy, or phyſics, viewed in its greateſt extent, would ſtill demand to render it complete and without defect, then this work may ſtill be regarded as an elementary treatiſe. It is thus that one of the literary monuments which moſt eminently honours our age, ſo remarkable for its progreſs in the ſciences; the immortal work of Haller on the philoſophy of the human body, bears the modeſt title of *Elements of Phyſiology*, though it is one of the moſt learned, the moſt profound, the moſt erudite, and the moſt extenſive that has ever been compoſed. Its illuſtrious author beſtowed on it this denomination of elements from a compariſon of what it was with relation to the powers of nature and thoſe other facts which are required for the diſcovery of its myſterious operations. Without doubt this title bears more particular relation to its great defects than to the labours which it required from Haller himſelf;—to the weakneſs of human nature rather than to the laborious efforts which it coſt its author. Under this point of view, the work which I publiſh, very far from reſembling Haller's work in its immenſity of reſearch, to which I do not pretend to compare it, though it has with it ſome other relations foreign to that of erudition, ſtill muſt, nevertheleſs, preſent to the philoſopher very imperfect elements of the ſcience of nature, to which I conſecrate it.

But it is not thus that we ſhould examine ſcientific works, when the uſes are conſidered to which they are deſigned. The elements of the ſciences, far ſhort of the grandeur and majeſty of nature, of which they ever will be the feeble outlines and very imperfect deſigns, can only be ſimple repreſentations of the firſt and of the moſt general truths which have been obtained concerning natural phenomena. Long details, profound diſcuſſions, great collections of numerous facts are entirely foreign to them, and only tend to withdraw the attention of the ſtudent.

As they are compoſed for the purpoſe of initiating in the firſt principles of ſcience, men who poſſeſs no previous knowledge, it is neceſſary they ſhould be accommodated to minds yet unprepared in the ſtudy, that they ſhould be ſimple and preciſe, that they ſhould contain only the ſimple enunciations clear from the maſs of proofs, digreſſions, explanative details and complicated facts. Such was the method of conſidering and proceeding in the compoſition of the Philoſophy of Chemiſtry. I may perhaps have even carried my preciſion too far; brevity may perhaps have rendered me obſcure, a fault which I ſhall endeavour to amend in another edition: but I was more deſirous of exciting reflection and meditation, of leading the readers to conſider the axioms which compoſe this work, than to miſlead him in the labyrinth of details, or load him with verboſe diſcuſſions and explanations.

When men engaged, in the ſtudy of natural ſciences, have acquired the firſt notions which elementary books preſent to them; when they are penetrated by the original truths which are there announced, and are become familiar to them: they then become capable of proceeding to greater depths, of comparing the different and more compounded facts, of diſcovering deſiderata and difficulties, and of comprehending all the delicacy and ſublimity of the ſcience. Thus qualified, they may and ought to read works more advanced, more difficult, and more extended than the ſimple elements. They alſo, require at this period of their ſtudies, treatiſes more developed, more profound,—learned diſcuſſions, maſſes of facts, more calculated to give light and conviction to minds now become more faſtidious, and, at the ſame time, more ardent in reſearch. Simple inſtruction without diſcuſſion or collateral proof is now inſufficient. They will be delighted to contemplate the proofs of facts, the objections of critics, and the diverſity of opinions: far from being diſcouraged by details or confuſed by difficulties, they earneſtly ſeek the one, and endeavour to overcome the others. It is alſo proper to ſhew to them the defects with which the ſciences ſtill abound, the obſtacles which remain to be ſurmounted, the phenomena which have not yet been explained, in a word, to compare for themſelves what they poſſeſs of reality, certainty, and demonſtration, with what is only probable, or the ſimple outlines, or views only to which they lead; in a word, to open to them their whole career without pretending to conceal the facts which are obſcure or imperfectly known, and the little ſpace yet cleared, when compared with what they have to acquire. Thoſe ſubjects which would fatigue or diſcourage the beginner whoſe ſteps ought to be directed with certainty, and in proportion to the weakneſs of his power, are well adapted to the acquired force of thoſe who have overcome the firſt difficulties, and who, if conducted in the true and perſpicuous courſe of elementary knowledge, will burn to engage in all the ſubordinate inquiries which have been concealed from them. He who is already ſkilled in the principles of the ſciences, and their elementary notions;—who feels a real diſpoſition for reſearch, will require not only all the details, and the moſt extenſive knowledge of facts, but alſo an exhibition of all the means which have been adopted to arrive at that knowledge, to ſeize from nature her minuteſt ſecrets and to penetrate the myſteries which ſhe has veiled from our eyes. Then it is that by truly appreciating the genius of the ſciences, by eſtimating all their reſources and by contemplating their ſpirit and their difficulties, they at length behold their connection with the power and the phenomena of nature; they can then make uſeful applications, and form a proper eſtimate of the pleaſure and advantages derived from this ſcience.

This is the object to which it was my intention to direct my new work. Deſigning it for thoſe who wiſh to ſtudy chemiſtry in all its minute parts, I have conceived it as of ſuperior rank to the Elements, under whatever form I may have varied them during the laſt twenty years. As the project which I have been deſirous of executing, embraces a ſyſtem of eight views which have not yet been preſented in any treatiſe of chemiſtry, I think it proper to explain with ſufficient development in this place, the extent of my plan and the means which I have uſed in endeavouring to carry it into effect.

All the branches of chemical knowledge, conſidered in that vaſt extent which they comprehend for thoſe who wiſh to acquire them completely, and who feel the courage to ſtudy them till they ſhall have obtained that ſtate to which our age has carried them, may be divided into four great parts, all equally independent of each other, or at leaſt capable of being detached and treated ſeparately, though they are all eſſentially related, and though their reunion may be regarded as neceſſary to conſtitute the perfection of the ſcience:

The firſt is the theoretic part, or the THEORY of the ſcience.

The ſecond comprehends its HISTORY.

The third appertains to the PRACTICE.

And the fourth includes its APPLICATIONS.

Let us take a view of the nature, the difference, the reſpective analogies and the relative diſpoſition of theſe four parts, which envelop and circumſcribe, as within an immenſe circle, the whole maſs of chemical facts.

By the THEORETIC part of chemiſtry, I mean to denote a methodical expoſition of all the facts belonging to that ſcience, and which, in the regular diſpoſition they ought to poſſeſs, as well as in the ſimple enunciation of the reſults they afford, preſents them equally diveſted of the experimental details or proofs which belong to the practical part; and of the different proceedings by which the human mind has been enabled to diſcover them, as well as of the hiſtory, and the numerous data they afford for explaining the phenomena of nature or the proceſſes of the arts, which alſo belong to the department of applications. This firſt part of chemiſtry, being truly the ſcience, of which the aim is really to exhibit the whole of the facts and to connect them together by an accurate method, ought to be treated ſeparately and in the firſt place; not only becauſe the objects it embraces being numerous and extended would be rendered confuſed by aſſociation with the three others; but alſo becauſe they conſtitute the baſis of chemical knowledge, and muſt naturally precede every other ſubject, conſiſting only of proofs, reſults, or dependent parts. No one can be a chemiſt without poſſeſſing the theory; no progreſs can be made in the ſtudy of either of the three other parts, if the grand developments which the theory affords to the principles of the ſcience do not precede theſe ſecondary parts; in a word, he only is the chemiſt who is well acquainted with it, though no one can become a profound and inventive chemiſt but by ſubſequent application to the other departments.

The HISTORY of chemiſtry, conſtituting in my plan, the ſecond part of thoſe extenſive departments of information which comprehend the whole of the ſcience, is not what is uſually underſtood by this name in the greater number of chemical books. The firſt pages of theſe treatiſes, the introductions, the preliminary diſcourſes ordinarily preſent an imperfect ſketch of the principal epochs or periods of the ſcience;

ence; a ſketch, decorated to no purpoſe with the title of the hiſtory of chemiſtry, with regard to the manner in which I apply theſe terms in my work. This part, which I regard as a complete and very eſſential member of the ſcience, taken in its utmoſt extent, requires details and developments of which there are only very incomplete ſketches in the works we poſſeſs. It ought not only to conſider and fix all the epochas of chemiſtry, to diſtinguiſh them carefully from each other, but even to examine all the diſcoveries made at different periods, to ſhew their connection with each other, their ſucceſſion, the progreſſion they have followed, the manner in which each truth has been diſcovered; it ought to notice the errors which were neceſſarily overthrown before the accurate diſcovery of obſerved facts; it ſhould apply this method of preciſe hiſtorical reſearch to each of the facts in particular, and particularly to thoſe of the moſt importance, becauſe they form the baſis of the ſcience. It follows, no doubt, that the hiſtory of chemiſtry, viewed under this relation, inſtantly demands that the reader ſhould have a poſitive knowledge of the facts which compoſe it, and conſequently that it ſhould be preceded by the theory of the ſcience. For this reaſon, I place it in the ſecond rank, to occupy the ſecond part. By examining all the details of the labours of chemiſts, from the earlieſt periods to the moſt modern times; by enumerating the long liſt of difficulties which retarded the elder chemiſts, the errors they committed, as well as the ſucceſſes they have obtained, we ſhall ſee how the general theories ſucceeded each other; why they at firſt preſented great vacancies or deſiderata; by what happy circumſtances theſe gradually diſappeared: and by this means the ſcience will be truly inveſtigated, the connection of its facts will be well determined; and its hiſtory, preſented under this uſeful form, will exhibit an intereſt of which it has not yet appeared capable.

The third part of that general chemiſtry, of which I have conceived the plan, includes the PRACTICE of the ſcience: it contains the claſſification of the inſtruments, the veſſels, and the apparatus of every kind; the ſeparate deſcription of each of their differences, of the variation of their forms, and materials, of their uſes, the changes which they have undergone, the improvements they have ſucceſſively experienced, the manner of uſing them to the utmoſt advantage. It conſiſts of a deſcription of a chemical laboratory, of the utenſils which are placed there, and of the means of employing them in the diſcovery of chemical truths. From this firſt baſis of the practice, it is proper to paſs to the deſcription of experiments, of operations, of proceſſes, of their differences, of the methods and manipulation neceſſary to obtain the reſults and products which form the objects of reſearch. This part, ſo neceſſary to the chemiſt by profeſſion, ſhould be detached from that which is taught by the theory, and alſo from that which the hiſtory comprehends; becauſe the long details which it requires would obſcure the clearneſs which ought to reign in the former, and, mixing without advantage with thoſe which belong to the latter, they would themſelves loſe that perſpicuity which is their leading merit and indiſpenſable to their real utility. Hence, it is requiſite that it ſhould form one of the primitive branches of the trunk of ſcience, diſtinct from the three others, and be treated by itſelf. Although, during the laſt ſixty years, a great number of valuable and uſeful works have been publiſhed under the titles of *Practical Chemiſtry*, *Experimental Chemiſtry*, *Chemical Proceſſes*, and *Manuals of Chemiſtry*, the ſcience is almoſt totally without a complete deſcription of its proceſſes, its manipulations, of its apparatus and of its modern experiments. The formation of a work of this kind, it is true, involves great difficulties; but it is of ſo great importance in explaining the advantages of chemiſtry, and to extend a taſte for it, as well as the manner in which it obtains all its new reſults, that it is extremely deſirable that it ſhould be made a leading object.

Laſtly, I conſider as the fourth and laſt part of the ſcience of chemiſtry, conſidered in all its extent, the APPLICATIONS which may be made, both to underſtanding and explaining the phenomena of nature, and the proceſſes, to the practice and to the improvement of the arts. This part is as vaſt in its execution and extent, as it is important by the ſervices which it has rendered and continues to render to ſociety. It is alſo towards this object, namely, the applications, that the efforts of chemiſts ought to be and in fact are directed: it is by theſe that we may hope to bring into the rank of exact and poſitive ſciences, mineralogy, geology, meteorology, almoſt totally abandoned at preſent, the firſt to a nomenclature nearly ſterile, the ſecond to romances or to a ſpecies of improbable or imaginary fictions, and the laſt to ſeries of obſervations ſo incoherent, and ſo independent of each other, that their uſeleſs maſs is an oppreſſion to philoſophers. In the ſtudy of the properties of vegetables, the chemical applications or the data of chemiſtry are alone capable of giving that light, which the obſervations of naturaliſts, notwithſtanding their number and their ſagacity, have not yet been able to afford: theſe alone can throw light upon the vegetable phyſiology and agriculture, as ſo many of the modern diſcoveries at preſent prove. It is equally well known that theſe diſcoveries will afford a number of truths in the natural philoſophy of animals and in medicine: what has lately been effected in many principal points of phyſiology, proves that there is more to be expected from chemiſtry than from all the other ſciences applied to animal phyſics, ſince anatomy, the moſt important of the latter, notwithſtanding its preſent accuracy and perfection, has preſented no diſcoveries of equal value. After this principal branch of chemical applications to the phenomena of nature, how important are thoſe which are relative to the arts! All the manipulations by which the properties of natural productions are changed, to render them, by a thouſand forms and new qualities, uſeful to our different wants, are truly the operations of chemiſtry. The chemical arts depend ſo much on that ſcience, they are ſo combined with its proper exiſtence and its advancement, that all the ſteps which it makes in the knowledge of bodies, all the diſcoveries with which it is daily enriched, are ſo many new acquiſitions for the arts; it perpetually improves them, adds to their proceſſes and creates new ones. Hence it is evident of what prodigious extent this fourth part of chemiſtry is ſuſceptible: it is evident that it may be divided into ſix branches equally important; three of applications to the ſciences, to the philoſophy of mineral, vegetable and animal, and three of applications to the chemical arts; namely, thoſe which are exerciſed upon foſſils, thoſe which are occupied on the products of plants, and thoſe which relate to animal matters.

Though theſe four parts appear to be equally neceſſary for the completion of the general plan which I intend to follow, it is nevertheleſs eaſy to conceive that each of them may be treated ſeparately and publiſhed alone. The intire work demands ſuch inceſſant and long continued labour, that it is probable the life of one man is inſufficient to terminate it completely. I have long collected materials and meditated its execution. The firſt part or general theory of the ſcience is completed in the work which I here preſent to the world. The ſecond has already been traced, though indeed as a mere ſketch, in the third volume of the Dictionary of Chemiſtry, forming part of the Encyclopædia. As to the other two parts, I have hitherto occupied myſelf only in collecting certain materials which will enter into their compoſition. Thus the SYSTEM OF CHEMICAL KNOWLEDGE which I now publiſh, and of which this diſcourſe is the preliminary introduction, forms in reality the firſt part of the great work of which I have announced the general plan.

The title of the preſent treatiſe nevertheleſs announces that it contains at leaſt a ſummary of the fourth part, namely, the applications of the ſcience. But I muſt here explain the notions which have directed my pen, and the reaſons that have induced me not to execute rigorouſly the firſt project, ſuch as I have here detailed it. If it had been permitted me to hope, or if I could have been ſure that the complete execution of the project and the formation of the four parts which compoſe it, could have taken place, I ſhould doubtleſs have followed that plan with the greateſt ſtrictneſs, and each of the four parts would have been treated by itſelf and without mixing any thing which belonged to the three others. I have ſhown that the firſt part, given ſeparately to the public as a treatiſe complete in its kind, capable of appearing and continuing in the literary world without being followed by any of the three following parts, ought at leaſt to preſent ſome ſketches or conciſe views, ſome of the leading outlines of the other parts, as well to break the didactic monotony, which would not have become an indiſpenſable duty except in the caſe of the other parts having been publiſhed at the ſame time, as to unite a notion, ſuperficial indeed but nevertheleſs uſeful, of the nature and of the advantages of each of theſe parts of the ſcience. Thus, in the ſketch of objects, according to this plan foreign to the theory of chemiſtry, I have limited myſelf to exhibit ſome leading examples of its application, by chooſing the moſt important and uſeful. I have in like manner choſen among the hiſtorical facts and the operations or proceſſes of chemiſtry, the moſt prominent and moſt proper to give an idea of the actual ſtate of the practice and of the hiſtory, at leaſt ſuch as I conſider them: ſo that the ſyſtem of facts which I have been deſirous of preſenting to ſtudious men, though relating to the theory of the ſcience rather than to its other parts, may nevertheleſs ſerve inſtead of thoſe parts, till time and the continuance of my labours ſhall have procured for them theſe laſt parts drawn out ſeparately.

Though I have thus intermixed the theoretic truths of chemiſtry with certain traits of its hiſtory, with many practical facts, and with its principal applications to the ſciences, the arts, and the other branches of human knowledge (theſe three kinds of notions having been conſidered here merely as acceſſories to the theory which forms the baſe of this work) yet it muſt be underſtood that the détails which relate to them have neither the extent nor the development which would have been neceſſary if I had treated them ſingly. The hiſtorical part is abſolutely no more than a ſlight ſketch, a ſort of firſt line required inſtead of leaving the names and the labours of thoſe able men intirely unknown to whom it owes its principal diſcoveries on each ſubject. Notions of manipulation and experiment are here traced with a conciſeneſs which is ſufficient to explain how far the actual proceſſes of the chemical art differ from what they formerly were, but not to deſcribe the operations exactly, ſo as to form the practical chemiſt. In ſhort, the principal applications which are here inſerted, being preſented with great preciſion, have no other purpoſe than to explain the great advantages with which the cultivation and the profound ſtudy of chemiſtry are accompanied, and the ſervices which it is capable of rendering to man. They require only to be conſidered as the titles or ſummaries of the work, or rather of treatiſes which will hereafter be publiſhed when it ſhall be required to give to them all the neceſſary ſcope and development. But among theſe applications there are two which I have thought proper to develop ſomewhat further, on account of the great intereſt which they excite with regard to the immenſe and immediate advantage which they promiſe to natural philoſophy, and of the clearneſs and certainty they have derived from the actual ſtate of chemiſtry, of which no one would have thought them ſuſceptible twenty-five years ago. Theſe relate to the philoſophy of vegetables and of animals, as I ſhall ſhew in the ſketch of the method which I have followed for the compoſition and the formation of this work.

In the foregoing pages I have ſtated the manner in which the principal revolutions, the preſent ſtate of chemiſtry, the rank which it deſerves among the ſciences, the advantages obtained from its cultivation, and more eſpecially its extent, as well as the firſt diviſion of four parts into which I apprehend it ought to be at preſent divided, when it is propoſed to proſecute the ſtudy with the utmoſt effect. I have ſhewn that the work which I now publiſh is, properly ſpeaking, only the firſt part of the great work of which I have formed the plan, and for which I have not ceaſed to collect materials during twenty years. It muſt be perceived that the true aim of this work is to offer to ſtudents a ſyſtematic body of the theoretic knowledge which conſtitutes the ſcience of chemiſtry. I ſhall now proceed to ſtate how I have diſpoſed theſe facts, the new order which I have adopted to form a methodical ſeries, the principal ſources whence I have procured them, and the courſe I have followed in its conſtruction. I muſt communicate to thoſe who take this work for the guide of their ſtudies, the line of direction according to which I have proceeded, that they may never depart from its courſe, but may always have preſent in their mind that conſtant connection which I have endeavoured to eſtabliſh between all the facts, and be enabled to judge by their progreſs in theſe ſtudies, whether I have completely fulfilled the purpoſe which it was my intention to accompliſh.

It has hitherto been a kind of cuſtom generally adopted, which by convention has become almoſt a law, to follow the method of the naturaliſts in works on chemiſtry; to divide theſe works into kingdoms, as in digeſting a courſe of lectures, and to treat each of theſe kingdoms in ſucceſſion, by deſcending even to their minuteſt diviſions. This courſe being the ſame as that of natural hiſtory, has been principally admitted by writers on chemiſtry, ſince the period when that ſcience began to ſhake off the yoke of pharmacy, under which it had for a long time been placed. When the principles of chemiſtry were generalized, more extended notions than thoſe of the mere preparation of medicines were embraced; when this ſcience pretended to a knowledge of all the productions of nature, it of courſe aſſociated with naturaliſts, and became directed by them. Before that period, chemical works were mere formulæ of pharmaceutic preparations, and neceſſarily preſented diviſions or a method intirely founded on the relations and the differences of theſe preparations.

At preſent chemiſtry ought to act, with regard to natural hiſtory, as it did near a century ago, with regard to pharmacy, though much more aggrandized by this laſt aſſociation than by the former to which it owed its origin, and from which it could not be ſeparated till after it had acquired a certain increaſe. It ought at preſent to experience the deſire as well as the neceſſity of proceeding alone without foreign ſupport, ſince its courſe is ſo well diſtinguiſhed from that of the other ſciences; and ſince its purpoſe, its means, and its reſults differ ſo eſſentially from them. Some authors have already felt this neceſſity, and have attempted to modify and even to change the order followed till their time. It was thus that the academicians of Dijon, in the elementary work which they publiſhed in 1777, as the baſis of their lectures, without confining themſelves to the diviſion of kingdoms, adopted for their text the new method of ſolvents and ſolutions, that is, the baſis of affinities or chemical attractions,

tractions, but conſidered with regard to ſolution, the principal phenomenon or the moſt general and beſt known operation of chemiſtry.

Convinced, ſince the conſolidation of the pneumatic doctrine and the publication of our methodical table of nomenclature, which in 1787 already afforded an expoſition of bodies chemically conſidered under a new form, that it is indiſpenſably neceſſary to adopt for the theory of chemiſtry an order completely peculiar, and excluſively appropriate; that is to ſay, founded on the information it affords reſpecting the nature of bodies, I ſaw that the method which it is neceſſary to adopt ought completely to differ from thoſe of the naturaliſts. In fact, they conſider bodies only as they are preſented by nature, in the poſſeſſion of the whole of their properties. They are even obliged to ſuppoſe them permanent, in order to ſeize with accuracy their forms, dimenſions, colours and apparent ſtructure; if they wiſh to fix, by the regular diſpoſition of their collections, the ideas of thoſe who ſtudy them, on the characters of the natural productions which they have adopted, it becomes neceſſary they ſhould abſtract from thoſe productions all the cauſes of change and of deſtruction which threaten them. The anatomiſt, guided in his firſt ſteps by the method of the naturaliſts, as ſoon as he has deſtroyed the connexion of the parts of vegetable and animal bodies, in order to become more intimately acquainted with their organization, can himſelf no longer permit the natural characters to remain as his diſtinguiſhing marks, and ſoon perceives the neceſſity of ſeeking for others from the interior texture of theſe beings: the beſt and moſt uſeful proceeding he can adopt, is to find in the concealed organs a relation or ſimilitude of ſtructure with the exterior parts, a relation from which, after the manner of Ariſtotle, general inductions are ably drawn, which render the diſtinctions of the methodiſts founded on the apparent or ſenſible characters more exact and luminous.

But the chemiſt can have neither the ſame progreſs nor the ſame object: no ſubſtance in his reſearch remains in its natural ſtate; he deſtroys its texture; he ſeparates its integrant parts; he cauſes all its properties to diſappear. At the firſt moment he deſtroys all its exterior or apparent characters; and though the natural method is calculated to guide him in the choice of the ſubjects which he examines, he is ſoon obliged to ſacrifice it intirely to his operations; he ſeeks and he finds reſults abſolutely different and in a certain degree oppoſite to thoſe of the naturaliſts. By ſubmitting bodies to analyſis, he diſcovers their intimate nature; he determines what is the order of their ſimplicity or their compoſition; he cauſes the properties which form their ſenſible or apparent characters quickly to vary; he ſtudies the attractions which the conſtituent principles of bodies obey;

and,

gen and air, azote, hidrogen, carbon, phoſphorus, ſulphur, diamond and metals. Theſe bodies are diſpoſed, the three firſt on account of their great maſs in nature, the manner in which they ſtrike our organs, the ſtrong and continual action which they exerciſe; in a word, of the generality of their exiſtence and of their extenſive agency in the economy of nature; theſe are light, caloric, oxigen: the two following, air and azote, after their analogy and independence of the three preceding; and the ſix laſt, according to the order of attraction which they have for oxigen, or the energy of their combuſtibility All are then reſpectively arranged in a ſeries approaching as much as was poſſible to their natural order, and, at the ſame time, to their chemical properties.

The hiſtory of each of theſe bodies is treated with all the extent and detail which their importance demands. Their phyſical properties, the different ſtates in which nature preſents them, the combinations they form among themſelves, their uſes, the influence alſo which the diſcoveries that relate to them have had on the reaſon and proſperity of man:—theſe conſtitute the particular hiſtory of ſimple bodies. The peculiar manner in which each of them is capable of burning, the different degrees of their combuſtion, of their oxidation or of their acidification, the various phenomena of flame, of colour, and of movement which accompanies their combuſtion; the ſeveral degrees of temperature which take place, the various reſults which it affords, are principally what have demanded the moſt care among the properties of theſe bodies, becauſe they are of the utmoſt intereſt in the preſent ſtate of chemiſtry.

Though I have not pointed out all the facts which the ſcience poſſeſſes concerning the primary beings not ſuſceptible of decompoſition, I muſt obſerve that the expoſition of their properties comprehends many more details, and facts more preciſe than any work of chemiſtry has yet preſented. This aſſertion being likewiſe applicable to the chemical hiſtory of all other bodies, and conſequently to all the articles of this work, I have made it in this place when I ſpeak of the ſection, where, for the firſt time, certain natural bodies are particularly examined. This obſervation may more particularly be applied with regard to oxigen and oxigen gas, the air, azote, azotic gas, and phoſphorus.

The hiſtory of carbon and of the diamond has been enriched by certain facts ſince the impreſſion of the firſt volume of my work. The beautiful experiments of Citizens Guyton and Clouet have proved the identity of the baſe of theſe two bodies, not only by the carbonic acid, the undoubted product of the combuſtion of the diamond as well as of carbon, but even by ſteel which is formed by the firſt of theſe bodies as eaſily and perhaps more ſo than by the ſecond, by heating it with pure iron. The proportion of oxigen which the diamond requires to burn it, and which amounts to four times its weight, whilſt that which is neceſſary for charcoal is only 2,527 for one part, and the quantity of carbonic acid which it affords, have confirmed the ſuppoſition which ſome chemiſts had already formed, that charçoal is a true oxide of carbon, on account of the proportion of oxigen which it contains; whilſt the matter of the diamond is pure carbon, poſſeſſing merely a degree of condenſation and aggregation ſuperior to that of all other known bodies. This fact, which was only announced in the articles of theſe two bodies, and which appears to require that theſe ſubſtances, the diamond and carbon, ſhould hereafter be ranged in the ſame article as one and the ſame ſubſtance, proves alſo that the black colour, the perfect opacity, and all the degrees of phyſical properties which depend on it, are not the characters of carbon, but of its oxide. This accounts for the white colour of vegetable matters the moſt replete with carbon; the black which they aſſume by oxidation and dis-hidrogenation; the perfect tranſparence of the diamond; the ſpecies of ſoot which Lavoiſier has firſt deſcribed, and which I obſerved long ago on the ſurface of diamonds partly burned, and interrupted in their combuſtion. It will be ſeen, in the hiſtory of the metals, that there are ſtates of carbon intermediate between that of the diamond and charcoal, where it contains leſs oxigen than this laſt, 0,03 or 0,04, and which are ſpecies of oxidules. Their characters are to burn very difficultly, only at a high temperature, to be extinguiſhed when this temperature is abated, and to produce with zinc and ſilver the galvanic irritation, which neither the diamond nor charcoal produce. Such are plumbago or carburet of iron, the anthracite or carburet of alumine, certain animal charcoals, and charcoal itſelf ſtrongly heated.

As to the article of the metals, it is neceſſary to bear in mind that they are placed in the ſecond ſection only in order to refer them to the firſt claſs of ſimple bodies or combuſtibles, to exhibit them as belonging to that ſeries of bodies; to prove, by the expoſition of their combuſtibility, that they could not be placed in any other claſs of bodies. Their importance, their great uſes, their number of twenty-one ſpecies, and the conſiderable quantity of combinations which they are capable of forming, require alſo that their hiſtory ſhould form a ſeparate diviſion; it is treated, with the great development it requires, in the ſixth ſection of this work.

NOTICE OF THE THIRD SECTION.

Concerning burned Bodies, Oxides or Acids.

IT was natural to treat of burned bodies, after having examined combuſtible ſubſtances; and as in the order or chemical claſſification of the productions of nature, theſe bodies form the ſecond claſs, their hiſtory ought to form the third ſection of my work. Accordingly its title is: *Concerning burned bodies, oxides or acids.*

It is divided into ſixteen articles.

The firſt has for its object an examination of combuſtion or of that phenomenon to which this genus of products owe their origin in nature as well as in art; it retraces in a rapid ſummary all the data already explained in the preceding ſection; it generalizes their reſults with relation to the nature of burned bodies, which are divided into oxides and acids; it gives the definition of theſe two kinds of products: the former are divided into permanent oxides, definitive or conſtantly remaining the ſame, and tranſitory oxides, intermediate between the ſtate of oxides and that of acids. I there have ſhewn that the oxides of the firſt genus may poſſeſs different degrees of oxidation, that thoſe, of the ſame combuſtible bodies, vary among themſelves in the proportion of oxigen they contain. I muſt here remark, that in order to diſtinguiſh theſe different oxides from each other, chemiſts may uſefully adopt the denomination of *oxidules*, propoſed, as ſimilar to that of acidules, by Citizen Haüy, and by which he repreſents the nature of metals in the moſt ſlightly burned ſtate.

The ſecond article is appropriated to the chemical examination of water or the oxide of hidrogen, one of the moſt permanent in the firſt genus of theſe bodies. I conſider it in its different natural ſtates, in its principal phyſical properties, its weight, its limpidity, its level, its cryſtallization, its characters when congealed, its fuſibility, its vaporization, its vapor formed, condenſed, &c. I then combine it with light, caloric, and, on that occaſion, I examine its fuſion, its ebullition, its dilatation, its gaſeity; phenomena concerning which I have given notions which I think more clear though much more preciſe than what has hitherto been written on that ſubject. Next come the combinations of water with oxigen, air, gaſeous hidrogen, its action on carbon, phoſphorus, ſulphur, the carbonated, phoſphorated, ſulphurated hidrogen gaſes, heated or cold, on the metals, and conſequently the hiſtory of its decompoſition. Hence it may be ſeen that I follow, in the expoſition of the chemical combinations or actions, the conſtant order of the bodies already treated; I uſe it alſo with regard to all the other bodies. I terminate this article by an explanation of the uſes and the effect of water in nature, as well as its relations ſo intimate with a number of other facts, and in general with the improvement of human reaſon.

In the third article, I ſpeak of the different ſpecies of metallic and non-metallic oxides, all ſubordinate to water by the leſs permanence of their combinations, and by the leſs degree of attraction between their radicals and oxigen. Theſe compounds are placed here only as it were proviſionally, and to afford an accurate ſeries in the knowledge of the oxides; becauſe their detailed hiſtory belongs as well to the ſection of metals, as to that of organized vegetable and animal compounds. Thus I only conſider them in a general manner, and in order to compare their properties with thoſe of water: I indicate their different ſtates, the changes which they experience by light, caloric, hidrogen, carbon, phoſphorus, ſulphur, the metals and water itſelf. The tranſient oxides of carbon, of azote, of phoſphorus, of ſulphur, and the complicated oxides, or ſuch as have binary radicals, of hidrogen and of carbon, are afterwards indicated, and I make a general diviſion of all theſe bodies into four genera, in order to throw light on moſt of the ſucceeding articles.

The fourth article has for its object the general claſſification of the acids, and preſents views and reſults concerning acidification which form at preſent one of the moſt important baſes of the theory of chemiſtry, though almoſt entirely neglected, or omitted in the greater part of modern works. The definition of theſe bodies, their acidity ariſing from oxigen, the particular diſtinction of thoſe which have the ſimple combuſtibles treated of in the preceding ſection for their radicals; their ſtate of acidity frequently of two kinds, according to the proportion of the acidifying principle, the rules of nomenclature deſigned to expreſs the nature and the ſtate of each; the generic characters of theſe burned compounds, taken, either from their phyſical properties, or from their mutual action on all the bodies formerly examined; in ſhort, the different methods of claſſing them, whether according to their decompoſition and non-decompoſition;—with regard to their gaſeous, liquid or ſolid ſtate;—the ratio of their energy;—or laſtly, by the different attractions of their radicals for oxigen; which laſt mode I adopt, becauſe it guides me through the greateſt number of my ſecondary diviſions. Such are the materials of this fourth article of generalities.

In the fifth, I conſider the carbonic acid, placed firſt among the acids on account of the ſtrong attraction of carbon for oxigen: the hiſtory of its diſcovery, and the different names which it has received from its gaſeous, liquid and ſolid ſtates in nature, where it is abundantly diffuſed;—the multiplied means of obtaining it artificially;

cially;—its characteriſtic properties under the form of gas;—its combinations with all the ſimple bodies before examined;—its union with water and with certain other oxides; of the carbonic acid when liquefied by its condenſation in water;—the natural and artificial acidulated waters;—laſtly, I give an account of the uſes of this acid and its numerous applications, both to the philoſophy of nature, and to ſocial proſperity, of which the diſcovery of its properties have been the fruitful ſource. The general reſult of the details contained in this article proves that the carbonic acid, though one of the laſt diſcovered, is nevertheleſs one of the beſt known, and one of thoſe which have had the greateſt influence on the progreſs and the renovation of the ſcience.

The ſixth and ſeventh articles preſent the hiſtory of the phoſphoric and phoſphoreous acids. A few years ago theſe two acids were confounded with each other. Though it was eaſy to diſcover, by means of the different properties which chemiſts announced in their combinations, that difference which exiſts between them, no one at that time poſſeſſed a preciſe idea of the diſtinction which ought to have been eſtabliſhed between the two acids. Hence the inconſiſtency and the contradiction, which formerly reigned among its compounds, have entirely diſappeared, becauſe, after the modern experiments, the two modifications of the acid of phoſphorous depending on its different combuſtion, have been well attended to.

The phoſphoric acid is placed the ſecond in the order of acids, becauſe phoſphorus comes immediately after carbon in its attraction for oxigen. I firſt give the abridged hiſtory of the diſcoveries which relate to it ſince the time of Stahl to that of M. Tennant. I then conſider its exiſtence in nature, its different means of fabrication, its different ſtates ſolid and vitreous, ſoft, gelatinous and liquid, its different phyſical properties, and its chemical relations to light, caloric, oxigen, azote, air, hidrogen, carbon, phoſphorus, ſulphur, diamond, metals, water, and carbonic acid; bodies which have all been ſtudied in the ſame order with the phoſphoric acid. Laſtly I indicate their principal uſes.

The phoſphoreous acid is treated in the ſame manner and with the ſame care. I principally inſiſt on its difference from the phoſphoric acid, on its diſtinctive characters, eſpecially on the phoſphoric light which inflames at its ſurface when it is ſufficiently heated, on the different methods of obtaining it; on its change to phoſphoric acid by different oxigenating proceſſes, and laſtly on its attractions and uſes which further diſtinguiſh it from the phoſphoric acid. I ſhould mention here that this is the firſt time that the two acids of phoſphorus have been treated with this detail and method in a ſyſtematic work of chemiſtry, and that I have conſequently digeſted theſe two articles with all the clearneſs of which they appeared to me to be ſuſceptible.

The eighth and ninth articles contain an examination of the ſulphuric and ſulphureous acids. The firſt of theſe acids is the third in order, with regard to the attraction for oxigen; the ſulphureous follows it immediately from a ſort of dependancy which requires that it ſhould never be ſeparated. After the various names of the ſulphuric acid, after a rapid hiſtorical ſketch of the chemical labours which relate to it, I have ſtudied it in its natural hiſtory; its preparation, whether its extraction, or its entire formation by art; its phyſical properties, and the effects of the attractions which all the preceding bodies exerciſe upon it, by dwelling upon caloric, air, carbon and water, matters whoſe actions are the moſt important to be determined with preciſion. I next explain the great advantages natural philoſophy derives from an exact knowledge of this acid, and its uſes in medicine and the arts. According to the experiments of Lavoiſier and of Citizen Berthollet concerning the nature of this acid, I have indicated its compoſition as formed of 0,71 of ſulphur, and of 0,29 of oxigen. I muſt add here that Citizen Thénard, an able chemiſt, employed at the polytechnic ſchool, has diſcovered, by new reſearches, made chiefly by burning ſulphur by the nitric acid, that 100 parts of ſulphuric acid contain 55,56 of ſulphur, and 44,44 of oxigen.

With regard to the ſulphuric acid, I explain its hiſtory with the more detail and care, becauſe though long known and employed, it is ſtill one of the ſubſtances leaſt attended to and moſt inaccurately treated in the greater number of chemical works. Its name, its hiſtory, its exiſtence in the native ſtate, the proceſſes of its fabrication, by burning ſulphur ſlightly, and by partially decompoſing the ſulphuric acid, its phyſical properties, its gaſeous and liquid ſtate, its various combinations with the bodies already treated of, its uſes in the arts and in medicine, its relation to the progreſs of the ſcience: this conſtitutes the ninth article, which is appropriated to it.

The tenth article is reſerved for the nitric acid, one of the moſt frequently employed, the moſt powerful, and the moſt uſeful re-agents which chemiſts at preſent have at their diſpoſal, and at the ſame time one of the beſt known and the moſt fertile in diſcovery ſince the happy revolution which the ſcience has experienced of late years: this acid deſerves, in every reſpect, to be ſtudied with the greateſt care and extent; and I have ſpared neither the one nor the other to explain its properties.

Its ſynonymy, its abridged hiſtory, its exiſtence in the natural ſtate, its formation by the electric ſpark acting on 0,20 parts of azote, and 0,80 of oxigen gas mixed, its extraction from the native nitrates by chemical attraction, its appearances and its phyſical properties, its weight, its taſte, its colour, and its white vapour, its acrid unpleaſant odour, its decompoſition by light, its volatilization and its decompoſition by caloric accumulated between its particles, its property of diſengaging elaſtic azote from animal matters, the abſorption of atmoſpheric water which weakens it, its action of inflaming ſimple combuſtible bodies, the ſlow or rapid decompoſition which it undergoes by theſe bodies, their converſion into acids by its proper oxigen, which abandons it more or leſs abundantly, its union with ſolid or liquid water, with the different oxides, its relations as to force and other effects with the acids which precede it, its difference from the former by the facility of the diſunion of its principles, the examination of the ſpecies of oxide which is diſengaged from it in gas when it is partly decompoſed or diſacidified by combuſtible bodies (oxide known under the name of nitrous gas, and which has become, ſince the modern diſcoveries, one of the moſt uſeful agents in a number of experiments, and prinpally in the analyſis of air or eudiometry) ; laſtly, a conciſe explanation of the uſes of the nitric acid and of the ſervices which it has rendered to the ſcience : theſe are the objects which compoſe the tenth article of this ſection.

With the ſame care and in the ſame method I ſtate the properties of the nitrous acid in the eleventh article. It was long known to chemiſts under the name of *ſmoking ſpirit of nitre,*

nitre, and taken for the acid of nitre, conſidered as more pure and ſtrong becauſe it poſſeſſes a deeper colour, and emitted a more abundant red vapour. This acid has not been well diſtinguiſhed from the preceding till after the conſolidation of the pneumatic doctrine. I have ſucceſſively explained how it is naturally formed, how it is fabricated, either by expoſing nitric acid to light, by decompoſing it ſlowly by a metal, or by diſſolving nitrous gas in that acid which rapidly abſorbs it; I prove that it differs or varies much according to the different proportion which it contains of that oxide, and that it is never identical, as is, for example, the ſulphureous acid; that it is ſaturated when 100 of the nitric acid have taken 90 of nitrous gas; that it has then the form of red vapour, almoſt incoercible, ſaturated with water, very volatile, eaſily ſeparated from the nitric acid, which condenſes it. I examine the effects of light, of oxigen, of azote and of air on this nitrous acid; its decompoſition ſtill more prompt than that of the nitric acid by combuſtibles, by reaſon of the great quantity of caloric which is united with it in this nitrous ſtate; I deſcribe its relations to water, the oxides, the acids whoſe hiſtory precedes it, its property of cauſing the phoſphoric and ſulphuric acids to paſs to the ſtate of phoſphoreous and ſulphureous acids; laſtly, I indicate with brevity its uſes and its influence on the progreſs of the ſcience. It is principally by attentive peruſal and ſtudious reflection on theſe two articles, compared with what has hitherto been written concerning the acid of nitre in the numerous works of chemiſtry, even of modern times, that the perfection to which this ſcience has arrived in the French pneumatic doctrine, and the extreme clearneſs which its principles capable of throwing on the phenomena of nature and of art, can be properly aſcertained.

In the twelfth article, I rapidly announce the general properties of the metallic acids. Among the twenty-one known metals, four only are capable of being acidified. Theſe acids, analogous to the ſeven preceding in the nature of their compoſition which is well known, are here compared to them only in their properties; I diſtinguiſh theſe from the others by their pulverulent ſtate, their harſh and metallic taſte, their very eaſy decompoſition, the ſlight ſolubility of moſt of them, their ſpeedy return to the ſtate of oxides, the ſtate which conſtantly precedes their acidity. Theſe four acids are only announced in the preſent article, deſigned to complete the ſeries of ſuch of theſe compounds as are well known by analyſis and ſyntheſis. Their detailed hiſtory muſt be reſumed in the ſection particularly conſecrated to metallic ſubſtances.

The thirteenth article commences another ſeries of acids, approaching to the preceding in the greater number of their properties, but which nevertheleſs differ from them ſingularly by their unknown nature, by the impoſſibility, as far as has hitherto been experienced, of decompoſing and recompoſing them completely. The muriatic acid, the particular ſubject of the article of which I ſpeak, is placed at the head of this ſeries, becauſe it approaches thoſe which precede it by the energy of its attractions. Hitherto it has always been reckoned among the mineral acids, and being almoſt conſtantly aſſociated with the nitric acid, it was formerly regarded as one of its modifications, as well on account of many of its effects, as its coexiſtence with that acid in the ſame places. Accordingly in former times it bore the name of *aqua fortis* like the latter acid; and a trace is ſtill perceived of that denomination in the title of *diſtillers of aqua fortis*, applied to thoſe who prepare both acids. In the hiſtory of the muriatic acid I have followed the ſame order as in thoſe of the preceding acids. The various names which it has had at different times, the art of extracting or of obtaining the muriates, its two ſtates gaſeous and liquid, the phyſical and chemical properties of its gas and of its ſolution in water, its ſpecific action on certain oxides and on the nitric acid; certain ideas concerning its intimate nature and its uſes, ſucceed each other in this article.

Since the impreſſion of this part of my work, Citizen Berthollet has publiſhed in a memoir read to the National Inſtitute, a ſeries of experiments concerning the artificial formation of the muriatic acid, from which it ſhould follow that that acid is compoſed of azote, of hidrogen, and of oxigen. He has obſerved that, in many caſes, where the nitric acid is decompoſed at the ſame time with water, muriatic acid is formed; and he has particularly ſtated as the principal circumſtances of that formation the decompoſition of nitre by heat, the abſorption of nitrous gas by the ſolution of the ſulphate of iron, and the ſolution of iron in the nitric acid, when filings of iron are added to it a ſecond time. He uſes the ſolution of the nitrate of ſilver poured upon the fluids afforded by the experiments indicated, to prove the preſence of the muriatic acid formed, by the precipitate of muriate of ſilver which it produces: but theſe experiments muſt yet be regarded only as notions proper to open the way to the knowledge of the muriatic acid, and they are not ſufficient to decide the nature of that acid. I adopt this reſult, 1ſt, becauſe the quantity of muriatic acid which may be ſuppoſed to be formed under theſe circumſtances is ſo ſmall, that it can not be appreciated; 2d, becauſe there is no proportion between the very ſmall quantity of acid formed, and the great quantity of materials which are employed to form it; 3d, becauſe even this ſmall proportion of acid which is thought to be formed may very eaſily have been precipitated from the matters employed, and have eſcaped the firſt reſearches; 4th, becauſe there is nothing in the experiments

ments which can explain the relative proportions of the three principles admitted as compoſing the muriatic acid; 5th, becauſe there is not yet any fact known concerning the decompoſition of that acid, which, as a ternary compound, ſhould ſeem to be much more decompoſable than it really is. To theſe firſt reaſons I add that Citizen Berthollet does not yet appear to be fully convinced of the reſult of his inquiries in that reſpect, becauſe he has not yet given them the publicity which ſuch a diſcovery is entitled to, on account of the great influence it would have on all the branches of chemiſtry. It may therefore be concluded from theſe conſiderations that the nature of the muriatic acid is not yet known, and that it is ſtill in the claſs of compounds of which the analyſis has not yet been made.

After the muriatic acid, in the fourteenth article, comes the oxigenated muriatic acid; an acquiſition ſtill new in chemiſtry. It is to the French chemiſts that we are indebted for the true knowledge of this body which is become one of the moſt powerful and the moſt uſeful agents that can be employed in analytic proceſſes. In all the properties which characterize the muriatic acid, there is none which diſtinguiſhes it more eminently from all the other acids, than that of being able to decompoſe many burned bodies, and take from them a portion of their oxigen, with which it combines. In this combination it acquires new qualities which I deſcribe in my ordinary method in that article, that is to ſay, placing it in contact with all the bodies examined before in the order in which I have conſidered them. I examine its ſtate of gas, its liquid ſtate, and its ſolid cryſtalline ſtate. I preſent it as decompoſable by light; acting on the greater part of combuſtible bodies as a powerful oxigenant; uniting difficultly with water, and differing much in that reſpect from muriatic acid, which diſengages it from that combination; deſtroying by its oxigenating effect a great number of colours and of odours; acting rapidly on our organs in a manner analogous to that of ſeveral other morbific cauſes; preſenting, in a word, to chemiſts a ſpecies of reagent, which may be conſidered as air extremely condenſed, or occupying a very ſmall volume. Laſtly, I indicate its principal uſes, and announce that it will hereafter become one of the moſt powerful means which medicine can employ to combat many ſevere diſeaſes.

The two laſt articles of the third ſection, the fifteenth, and the ſixteenth, treat of the fluoric and boracic acids, ſtill unknown in their conſtituent principles, and forming with it the ſhort ſeries of three unknown acids. Theſe are, in other reſpects, very diſtinguiſhable from all the other acids with which ſeveral chemiſts have in vain endeavoured to compare them by their intimate nature or the pretended analogies of their properties.

The

The firſt, the fluoric, conſidered in the ſtate of gas, and under the liquid form, preſents itſelf well characterized by its odour, its weight, its action on the hard ſtones and on glaſs, its weakneſs compared with the activity of many of the preceding acids, its total inactivity with regard to combuſtible bodies, as well as its inalterability and the reſiſtance which it oppoſes to their reaction.

The ſecond, the boracic acid, one of the weakeſt of all, is diſtinguiſhed principally by its ſolid and cryſtalline form, the weakneſs of its taſte and of its attractions, its fixity and vitrifiability, its ſparing ſolubility in water, and its exerting no action on the ſimple combuſtibles. In the deſcription of all its properties, I have not forgotten to mention the fruitleſs attempts which have been hitherto made to diſcover the nature of this acid, or the opinion of a modern philoſopher who, agreeing in that reſpect with certain ancient notions, conſiders it as a modification of the muriatic acid.

The outlines which I have here drawn of the order which I have adopted to explain the properties of burned bodies, oxides, or acids, for the relative arrangement, as well as the hiſtory of each in particular, will ſhew when compared with the diſpoſition of all the treatiſes hitherto written that none of them reſembles mine; that this part forms an entire whole which has not till now exiſted in the ſcience;

that every object is here connected by relations of which the pneumatic doctrine alone could afford the notion and the materials; that the new facts, owing for the moſt part to modern diſcoveries, are here connected with the ancient, and in a mutual dependence on each other; that the alterations as well between the conſtituent principles of theſe burned bodies, as between their entire compounds and other bodies, form the baſe of their claſſification; laſtly, that from all theſe united conſiderations there flows an agreement between the ſeveral truths which cannot fail to ſtrike the minds of ſtudents and give the moſt accurate and durable impreſſion.

NOTICE OF THE FOURTH SECTION.

Concerning the Salifiable Baſes, the Earths and Alkalis.

THE title of the fourth ſection is: *Concerning the Salifiable, Earthy, and Alkaline Baſes.* It is in fact employed upon the chemialc hiſtory of the earths and of the alkalis, matters which cannot be treated elſewhere than in the ſequel of the acids, becauſe they have great affinity with them; becauſe they are almoſt all, and almoſt always, found united to theſe compounds; becauſe, in ſhort, they form, in theſe combinations, the moſt frequent products of nature and of art, of whoſe exiſtence and characters it is impoſſible to be ignorant of without being deprived of the moſt important reſources of the ſcience.

It has been already ſhown that the earths and the alkalis form the third claſs of bodies conſidered chemically; that the greater part, though undecompoſed, announce to chemiſts, who frequently treat them in their operations, and by a ſufficiently great number of phenomena, an order of compoſition much more manifeſt than can even be ſuſpected in the undecompoſed matters forming the firſt claſs. I ſhall here add to this general notion, that the more we advance and the more progreſs we make in the examination of earthy and alkaline ſubſtances, the more the ſuppoſition of their compoſition is ſtrengthened, whereas the idea of ſimplicity always obtains further confirmation, and is increaſed in proportion as the properties of bodies of the firſt claſs are better underſtood.

The earths and the alkalis are here named *ſalifiable baſes* after Lavoiſier, becauſe their moſt eminent property, their moſt definite character is exhibited in the tendency which they have to form ſalts by their union with the acids; becauſe there are no ſalts properly ſo called without that union, and conſequently without their preſence; and laſtly, becauſe they determine the ſaline formation and nature by that combination.

This fourth ſection is divided into fourteen articles.

In the firſt, I conſider the ſalifiable baſes in general; I give an extenſive definition of them, I preſent their claſſification, and I ſpeak of the earths in particular. After having defined thoſe, and explained in what their earthy character conſiſts, I prove that the ancient notion concerning an elementary earth is an abſolute chimera; and that the more progreſs is made in the ſtudy of the earths, the more their number is found multiplied. I then diſtinguiſh ſix earthy matters very different from each other and well characterized: I divide them into arid earths or earths properly ſo called, to the number of four ſpecies, ſilex, alumine, zircone and glucine, and alkaline earths, of which two ſpecies are known, magneſia and lime. Their reſpective diſpoſition is founded on their attraction for the acids, in ſuch a manner that the firſt of them is the leaſt, and the latter the moſt attracted by them. By announcing their natural exiſtence in the ſtony compounds, from which the art of the chemiſt extracts them, I have remarked that none of them are yet known in their intimate nature, their decompoſition and their principles.

The ſecond article treats of ſilex, of its different names, its hiſtory, its exiſtence in nature, its extraction and purification by art, its phyſical properties, the manner in which it is acted on by all the bodies formerly examined, and its numerous uſes. Its ſolution in water and the acids, and a great number of phenomena which depend on it, are particularly treated, though they have been neglected by moſt ſyſtematic authors. The ancient opinion of the chemiſts, who regard ſilex as an earthy element, and the common ſource of all other earths, is but ſlightly indicated, becauſe, in the actual ſtate of our knowledge, that opinion loſes every day its force and its probability.

Alumine, which forms the ſubject of the third article, is treated with ſtill more detail than ſilex, though in the ſame order and method. It preſents a ſeries of chemical phenomena more remarkable than the preceding earth, on account of its great alterability and its ſtronger attractions. I have ſucceſſively deſcribed the manner in which it is acted on by heat, air and water; its affinities with the oxides and the acids; its adherence to carbone, which produces the ſpecies of combuſtible foſſil, ſo difficult to burn, named *anthracite* by the French mineralogiſts, to diſtinguiſh it from pit-coal, properly ſo called. I ſhew in what reſpects the ſtudy and the well-known properties of this earth have influenced the progreſs of ſcience and the arts which it directs, and I terminate this article by exhibiting the multiplied uſes to which alumine is applied in ſociety.

The fourth article, which treats of zircone, is much ſhorter and contains fewer details than the two preceding, becauſe this earth, known only ſince 1793, has not been yet examined, but by few chemiſts. After having deſcribed the means of obtaining it from the zircone, the jargon, and the hyacinth, I enumerate its phyſical characters and chemical properties, particularly its alteration by caloric, its general combination with the acids, and its differences from ſilex and alumine.

Glucine, the ſubject of the fifth article, diſcovered by Citizen Vauquelin, four years after the zircone, is ſtill leſs known. I firſt give the hiſtory of its diſcovery, then the reaſon of its denomination from its ſweetiſh taſte, and how its combinations with the acids are formed; thence I paſs to the proceſs of its extraction, and deſcribe its phyſical and chemical properties, and more eſpecially its attractions, which diſtinguiſh it from all the other earths. As to its uſes, it may be imagined that there are none yet, as well on account of its ſmall quantity, as becauſe it is yet very little known; I indicate however what we may hope for hereafter.

Long after the impreſſion of that article and of the ſection of my work of which it forms a part, we were informed in France (only in meſſidor of the 8th year, July, 1800) of a new ſpecies of earth very analogous to glucine, diſcovered three years before it, in 1794, by M. Gadolin, a Swediſh chemiſt. This diſcovery has been ſince confirmed by M. Ekeberg, who has named the new earth *yttria*, from that of *ytterby* given to the ſtone from which it is extracted, after the place where it is found. Citizen Vauquelin has ſent me the analyſis which he has made of this ſtone, and the examination of the particular earth which he has obtained. The following is the reſult of his labour.

Ytterby or Gadolinite has a black colour, and its powder is of a blackiſh grey, its fracture vitreous. Its ſpecific gravity is 4,097; it acts on the magnetic needle. When expoſed to the blow-pipe, it breaks in ſcales or ſplinters, and leaves a white matter which is not fuſible. When heated with borax, it is fuſed, and affords a button of a violet yellow. In the crucible it loſes 0,08 of its weight, and becomes red like ochre. Strong acids attack and reduce it into a ſpecies of greyiſh jelly: this jelly evaporated to dryneſs and waſhed, leaves ſilex in white powder. The diſſolved part contains iron and the new earth; the nitric acid by evaporation lets fall ſilex and the oxide of iron. The nitric ſolution of the earth which remains after the waſhings of the evaporated matter is mixed with a little lime and mangane ſe; ammonia ſeparates from it the earth in queſtion, together with a little mangane ſe. By re-diſſolving theſe two ſubſtances in the nitric acid, the mangane ſe is ſeparated by the hidro-ſulphuret of potaſh which leaves the earth; this is obtained by the addition of ammonia. By theſe proceſſes, as well as by fuſion with potaſh, ſolution in water, evaporation which ſeparates the mangane ſe neſe and ſubſequent treatment with the nitric acid, Citizen Vauquelin has been enabled to find in *ytterby* or Gadolinite the following matters :

Silex	25	
Oxide of iron . .	25	
New earth or *yttria*	35	
Oxide of magneſia .	2	
Lime	2	
Loſs	11	in carbonic acid and in water.

The earth thus extracted, or yttria, is white and fine ; it has neither taſte nor ſmell ; is infuſible ; forms with borax a white glaſs ; is not ſoluble in the cauſtic fixed alkalis, which diſtinguiſhes it from alumine and from glucine : it is ſoluble in the carbonate of ammonia, like glucine ; but it requires five or ſix times more of that ſalt than this laſt. The ſulphuric acid combines with it by heat, and is quickly precipitated in ſmall brilliant cryſtals, ſlightly ſoluble in water. The ſulphate of yttria is aſtringent, and afterwards ſweet like ſalt of lead : its taſte differs little from that of the ſulphate of glucine, and it requires fifty parts of cold water to diſſolve it. The nitrate of yttria is ſweet, very deliqueſcent, incryſtallizable ; inſtead of drying by heat, it fuſes or becomes ſoft like honey ; by drying it becomes ſolid and brittle like a ſtone : the ſulphuric acid precipitates cryſtals from the ſolution. The muriate of this earth poſſeſſes properties very analogous to thoſe of the nitrate. Ammonia precipitates yttria from theſe three acids; the oxalic acid alſo ſeparates it, forming a heavy denſe precipitate like the muriate of ſilver: this laſt phenomenon diſtinguiſhes it ſtrongly from glucine, which forms with the oxalic acid a very ſoluble ſalt. It is alſo diſtinguiſhed by the precipitation of the ſalts of yttria by the pruſſiate of potaſh, which does not precipitate the ſalts of glucine: it appears to have more attraction than this laſt, at leaſt for ſome acids. The compariſon of its properties led Citizen Vauquelin to admit a real difference between yttria and glucine, and to place the former among the diſtinct earths.

Magneſia, the ſubject of the ſixth article, begins to exhibit alkaline properties, and to differ, in this reſpect, from the four preceding earths. Confounded for a long time with the abſorbent earths, on account of its property of uniting eaſily with the acids, I ſhew in what manner it was diſtinguiſhed by Hoffman and by Black. Its different ſtates in nature, the art of obtaining it pure, its external characters, the action which caloric, air, certain combuſtibles, water and the acids produce on it, its combination alſo with the four preceding earths, ſucceſſively engage my deſcription. I ſhew that its intimate nature or conſtituent principles are no more known than thoſe of all the other earthy matters; and laſtly, I announce its uſes and application to the medical art.

The ſeventh article, one of the moſt remarkable of this fourth ſection, preſents the hiſtory of lime. The details conſigned to this article correſpond with the importanee of the matter which forms its ſubject. Little known, and the ſource of great errors even till the middle of the eighteenth century, lime has become, ſince the laſt revolution of chemiſtry, one of the moſt valuable agents which can be employed in accurate experiments. I ſucceſſively trace the hiſtory of the principal diſcoveries which relate to it, its natural hiſtory, its preparation by burning and by the proceſſes of the chemiſts, its alterability by heat, by air, its important combinations with phoſphorus, ſulphur, and hidrogen, its action on water, and that of this liquid upon it, the properties of its aqueous ſolution, or of the water of lime, its attractions compared with thoſe of the other baſes for the acids, its union by means of heat and water with ſilex and alumine. By explaining the different opinions of chemiſts and of naturaliſts concerning its intimate nature, I prove that nothing is yet known on this ſubject, and that whatever has been ſaid concerning its compoſition is intirely hypothetical. I enumerate the very many uſes to which this earth, the moſt approaching to the alkalis, is emplyed in a number of circumſtances, either for the treatment of diſeaſes, for the culture of the fields and rural economy, or in the very extenſive liſt of arts where it is very beneficially applied.

The eighth article, which bears for title *concerning alkalis in general,* explains the origin of that word, the alkaline characters and the enumeration as well as claſſification of their baſes. I there ſhew why I have rejected the letter *k* from that word, and I have ſubſtituted the *c ;* I announce that two of the baſes hitherto claſſed among the earths, namely, barytes and ſtrontian, will hereafter become, according to my method, part of the genus of alkalis, of which the number is thus increaſed to five; I diſpoſe them according to the order of their attraction for the acids, beginning with the moſt powerful alkali; I place in ſucceſſion barytes, potaſh, ſoda, ſtrontian and ammonia. Barytes and ſtrontian become truly the two fixed alkalis, becauſe they reſiſt fire much more than potaſh or ſoda. I mention the ſimilitude of the attraction of the alkalis with thoſe of the earthy baſes; I indicate their ſtates in nature the general mode of their combinations, their intimate compoſition ſtill unknown, except merely in the ſpecies of ammonia; I explain alſo the views which I firſt entertained concerning the conſtant preſence of azote, as the *alkaliſying* or *alkalizing principle;* but I have taken care not to preſent them otherwiſe than hypothetical notions which ought to be regarded as ſuch, till more accurate experiments than thoſe which have hitherto been made ſhall have permitted us to ſpeak decidedly in this reſpect.

The ninth article, appropriated to barytes, comprehends, after my ordinary method, its ſynonymy, its hiſtory, its ſtate in nature, its preparation, its phyſical properties, the effects which it experiences on the part of light, of caloric, of air, its union with phoſphorus and ſulphur as well as with ſulphurated hidrogen, its habitudes with water, the oxides and the acids, and its action on the earths. I treat largely, 1ſt, of the hidro-ſulphuret of barytes, a ſpecies of combination newly diſcovered; I deſcribe three kinds of compounds formed by this baſe with ſulphur, ſulphurated hidrogen, or theſe two bodies at once; namely, the ſulphuret, the hidro-ſulphuret, and the hidro-ſulphurated or hidrogenated ſulphuret of barytes, becauſe the ſame triple combinations are found among all the alkalis, and becauſe they are of much intereſt in the actual ſtate of the ſcience; 2d, on the extinction of barytes in the air, which is much more lively than that of lime; 3d, on the ſolution of barytes in water, more plentiful by heat than in the cold, and on the cryſtallization of this article; 4th, on its combination with the earths, which may be advantageous in the analyſis of ſtones; 5th, on its ſtrong attraction for the acids; 6th, on its poiſonous effects on the animal economy.

In the tenth and eleventh articles, I examine potaſh and ſoda with equal care, and ſtill greater extent. The facts which relate to them, all of which are of great importance, ſince we have learned how to diſtinguiſh theſe alkalis in their ſtate of purity from their combinations with the carbonic acid, which formerly paſſed for alkalis, are deſcribed methodically, and with an extent which correſponds with their importance; I have ſhown that potaſh is not an alkali excluſively belonging to vegetables, as has been believed; that it exiſts abundantly among foſſils, and that it appears to paſs from them into plants. I explain its preparation with ſome detail, becauſe this ſubject is ſtill ſlightly treated in ſyſtematic works on chemiſtry, then its phyſical and chemical properties, enlarging principally on its combination with ſulphur and ſulphurated hidrogen, on its union with water, on its attractions for the acids, on the compounds which it forms with certain earths, and its ſlight adherence to others, on the ſtill hypothetical notions which we are permitted to entertain of its intimate nature, and laſtly, on its uſes and the neceſſity of augmenting its production in France.

The ſame order and the ſame care are adopted concerning ſoda; its ſyonyma, its natural hiſtory, its extraction and its preparation, its external characters, its relations to light, caloric, air, combuſtible bodies, water, the oxides, the acids and the earths, are ſucceſſively examined. I have principally inſiſted on thoſe properties which excluſively belong to, and diſtinguiſh and, conſtantly occupied with particles ſo fine and delicate that they ceaſe to be viſible, he wanders far from the naturaliſt, who only obſerves the regular or organic aggregation of bodies in poſſeſſion of their form, their extent, and all the properties which depend on the perfection as well as the permanence of their compoſition or ſtructure.

It never has been for any purpoſe but to make himſelf underſtood with regard to the names of the bodies of which he had to ſpeak, that the chemiſt has followed the methodical diſtinctions of the naturaliſts; and as long as the ſcience in its infancy did not permit him to form a particular order, he could in fact do nothing better in order to avoid ſubſtituting fables or romances inſtead of facts of which it ſtill is in want. But hereafter his ſteps will be leſs cloſely connected with thoſe of the methods of natural hiſtory. Having ſucceeded by its late diſcoveries concerning the primitive elements of bodies,—on the eve of being able to claſs bodies after their intimate nature from the number and proportion of their conſtituent principles, chemiſtry has opened a new and peculiar courſe; and its method, at length independent, muſt ſooner or later become the leading ſcience of many branches of natural hiſtory, inſtead of continuing to be its ſimple acceſſary, as it appears ſo long to have done.

By comparing, under this new relation of intimate compoſition, all the bodies in nature with each other, for the purpoſe of forming a chemical claſſification, I have found that they may be divided into eight general claſſes, with regard to the difference even of their conſtituent principles.

In the firſt claſs, I have placed the ſimple bodies, or at leaſt ſuch as have not yet been decompoſed;—which appear in our experiments as ſimple bodies. Theſe are, in a great meaſure, the conſtituent elements of all other bodies. By conſidering the ſubſtances which belong to this claſs, it is evident that they all bear relation to combuſtion, ſome as products, others as conditions and moſt of them as ſubjects to that great phenomenon.

The order which I have adopted thus conducts us very naturally and very methodically from one claſs to another, becauſe the ſecond claſs comprehends burned bodies or thoſe of the firſt claſs, united by combuſtion to one of the ſubſtances alſo placed in the ſame claſs. Theſe burned bodies or ſpecies of binary compounds which form the ſecond claſs, and which all reſemble each other by their nature, as combuſtibles more or leſs ſaturated with a ſimilar principle, are the oxides and the acids with ſimple or undecompoſed radicals, which were formerly named mineral acids: they exiſt in nature as well as in art.

In the third claſs of chemical bodies, and next after the acids, I place as matters eminently capable of combining with theſe laſt, and which by indiſpenſable conſequence approximate to them, the earthy and alkaline ſubſtances, which I name with Lavoiſier ſalifiable baſes, on account of the property which they have of forming ſalts with the acids. Bodies almoſt every one of which being hitherto undecompoſed, and appearing in chemical operations as ſimple ſubſtances, though many appearances announce that they are not ſuch ;—their place according to my method is neceſſarily determined between the acids and the ſalts.

The fourth claſs includes the ſalts or chemical compounds of acids and of the ſalifiable baſes. It is extremely enriched by the numerous diſcoveries made during the laſt twenty-five years. Saline bodies form at preſent one of the orders moſt important, the moſt crowded with ſpecies, the beſt known, and which is the moſt uſeful to be well ſtudied, as will quickly be ſeen.

To the fifth claſs belong, according to my method, the twenty-one metallic ſubſtances at preſent known, which, though indicated and holding neceſſarily a place in the firſt claſs, as ſimple or undecompoſed bodies, have, nevertheleſs, ſo great an importance from their excellent qualities, from the numerous products which they furniſh to the arts, from their great uſe in ſociety, and, in ſhort, from the immenſe influence which their chemical examination has had on the progreſs and laſt revolution of the ſcience, that it is impoſſible to refuſe to them a ſeparate and diſtinguiſhed rank in the ſtudy of the productions of nature.

I compoſe my ſixth claſs of bodies, diſpoſed after their chemical properties or their order of compoſition, of all thoſe which are named foſſils or minerals. In order to underſtand properly my manner of proceeding with regard to the ſixth claſs, I muſt obſerve that the greater part of the ſubſtances ranked in the five preceding claſſes are uſually regarded as minerals, and placed as ſuch in mineralogical diviſions. But, beſides that many of them exiſt in the atmoſphere or in waters, which conſtitute by their maſs a fourth kingdom truly diſtinct from that which is named the mineral kingdom, it is certain that moſt of them forming in effect a portion of the ſtrata of the globe, are frequently impure, and ſo mixed or complicated, that chemiſts cannot treat them in their natural ſtate; and, in order to determine their characteriſtic properties, it is neceſſary to purify them, which they effect in ſuch a manner as to give them a form and ſtate truly different from thoſe which they have in nature. On the other hand, foſſils or minerals which more eſpecially comprehend the ſtones and the ores, and which are wrought in an hundred different ways for the arts, without being moſt frequently, either the one or the other, compriſed in the five preceding claſſes, at leaſt in their ſtate of purity, require nevertheleſs to be conſidered as compounds or as mixtures of theſe matters, and deſerve to be ſtudied apart as uſeful productions. For this reaſon, I have placed them in a ſeparate claſs. Beſides which the complete ſtudy and detailed hiſtory of theſe bodies conſtitute one of the ſpecial applications of chemiſtry, which is named mineralogy; and, under this point of view, they appertain to chemical theory in a general way only.

The ſeventh claſs of bodies, conſidered with regard to their intimate nature, contains the vegetable organic compounds, of a more advanced order of compoſition than the foſſils. The materials of plants require to be treated in chemiſtry under the title of vegetable compounds, much rather than under that of the vegetable kingdom; a denomination by which the ſtudy or the deſcription of plants, obſerved with all their organs and all their apparatus of ſtructure, without deſtroying their texture and without altering their compoſition, is uſually deſignated.

Laſtly, the eighth claſs is appropriated to organic animal compounds: theſe in the order of chemical conſideration, are the beings moſt complicated in their compoſition—thoſe which muſt be the moſt difficult to underſtand as to the number and proportion of their conſtituent principles, thoſe conſequently which it is proper to ſtudy laſt, and for the examination of which a knowledge of all the others is neceſſary.

Thus we behold all the products of nature divided into eight great chemical families, diſpoſed in the order of their compoſition or of their intimate nature; from thoſe which appear to be formed by the aggregation of the inſulated firſt principles, becauſe they do not admit of decompoſition, unto thoſe which contain the greateſt number of principles in their compoſition. They are placed in a ſeries which, by ſeparating them all methodically, nevertheleſs connects them with each other, and gradually conducts the ſtudent of their properties, from the moſt ſimple and the moſt determinate of theſe productions, to thoſe which are moſt difficult to be known. This method is neither factitious, nor arbitrary in its entire progreſs; it is founded on the general reſults of all the experiments of chemiſtry; it can never vary but with regard to ſome particular bodies, in the caſe where diſcoveries ſhall exhibit compound matters among ſubſtances reputed to be ſimple, or among the compounds, other bodies more complicated in their compoſition than have formerly been believed to exiſt there. It is, in ſhort, a method which, being deduced from the whole maſs of chemical facts, and deſtined to unite the ſyſtem into one aggregate, leaves exact and poſitive ideas in the mind reſpecting the nature of all bodies.

This methodical and regular diviſion of natural productions conſtitutes the firſt foundation of my actual ſyſtem and of the work which preſents the whole. But as the examination of minerals or foſſils ought not to be here treated with the detail which a work of application would demand, I have neither conſidered theſe bodies particularly, nor permitted their claſs in a certain manner to ſubſiſt. I have diſpoſed thoſe portions which belong to the theory of the ſcience in the different ſections of this work, without giving them the extent which would be required to conſtitute a mineralogy, properly ſo called.

The whole ſyſtem of chemical facts included in this treatiſe is divided into eight ſections: the following is an enumeration of their titles.

FIRST SECTION:

Baſes of chemical ſcience; Generalities; Introduction.

SECOND SECTION:

Of ſimple or undecompoſed bodies.

THIRD SECTION:

Of burned bodies, oxides, or acids.

FOURTH SECTION:

Of earthy or alkaline ſalifiable baſes.

FIFTH SECTION:

Of acids united with ſalifiable baſes, or of earthy and alkaline ſalts.

SIXTH SECTION:

Of metals in particular.

SEVENTH SECTION:

Of organic vegetable compounds.

EIGHTH SECTION:

Of organic animal compounds.

It is evident that ſeven of the claſſes of natural beings, conſidered chemically, form ſo many ſections of the ſyſtem; that the eighth claſs, or the ſixth in the order of claſſification which I have explained, is replaced by the firſt ſection, conſecrated to the generalities of the ſcience, becauſe the foſſils or minerals which compoſe that ſixth claſs are diſtributed into the ſecond, third, fourth, fifth and ſixth ſections, appropriated to explain ſubſtances, which for the moſt part are incloſed in the globe of the earth or form part of its ſtrata.

NOTICE OF THE FIRST SECTION.

Concerning the Generalities of the Science.

THE firſt ſection, as an introduction to the ſeven following, preſents the preliminary notions of chemiſtry, or the firſt principles of its ſtudy.

It is divided into twelve articles:

The firſt exhibits the definition of chemiſtry, its different names, its relations to and differences from the other ſciences; its various definitions and denominations are diſcuſſed; its place in the philoſophical order of human knowledge is aſſigned; an explanation is given to ſhew how it conſtitutes a ſcience diſtinct from phyſics, from natural hiſtory, from medicine, from pharmacy, and even from the moſt important and moſt extenſive of the chemical arts.

The ſecond article under the title of the diviſions and branches of chemiſtry, explains in ſome degree the ſpecies which this kind of ſcience includes, general or philoſophical chemiſtry, meteorologic chemiſtry, mineral chemiſtry, vegetable chemiſtry, animal chemiſtry, medical chemiſtry, economical or manufacturing and domeſtic chemiſtry. Each of theſe branches may be regarded as one of its applications in the general order in which I have before conſidered it.

The third article preſents a rapid hiſtorical ſketch of chemiſtry; under ſix epochas are exhibited the great revolutions which it has experienced; the names and principal diſcoveries of men who have founded or enriched it are given; and the origin and conſolidation of the pneumatic doctrine of the French chemiſts, which appears to have fixed the fate of chemiſtry for ſome ages, is more particularly ſtated.

The fourth article treats of the chemical nature of bodies; the principles which chemiſts have admitted at different times in their compoſition; the opinions of the ancient philoſophers in this reſpect; the ideas of Paracelſus, of Becher, of Stahl, the more accurate diſcoveries of modern times, the different ſpecies of compounds, and the order to be eſtabliſhed in this reſpect. It is there proved that the four elements of Ariſtotle can no longer be admitted; that the primitive elements of bodies are totally different from what they have been hitherto thought, and that they now begin to be explained, after the long and antiquated hypotheſis which have alone prevailed in the learned world.

The fifth article conſiders the analyſis or ſeparation of the principles of bodies by the proceſſes of chemiſtry, as one of the means by which that ſcience arrives at its object. In this place I diſtinguiſh a more conſiderable number of ſpecies of analyſis than any one has formerly done; I prove that the accurate and extenſive ideas which may be acquired in the ſcience of chemiſtry, depend much on the clearneſs of thoſe notions which are acquired at the commencement of the ſtudy, and that it is very important to comprehend all the reſources, all the difficulties, all the differences which exiſt in each kind of analyſis.

The ſixth article preſents ſimilar conſiderations reſpecting ſyntheſis or combination, the ſecond operative means of chemiſtry; it may alſo occur more frequently than the former, which has long been confounded with it, becauſe it takes place at the ſame time, and becauſe it alſo produces phenomena the moſt complicated and the moſt difficult to be well underſtood, of any which the operations and the experiments of chemiſtry afford.

In the ſeventh article, wherein the ſubject begins to be more complicated than in the ſix former, which contain only a few explanations, ſimple and eaſy in their object, reſpecting the nature and purpoſe of the ſcience, I enter more deeply into the ſubject by treating of the attraction of aggregation. This power, eſtabliſhed by nature between the integrant and homogeneous particles of bodies, cauſes them to adhere to each other in ſuch a manner as to give them a conſiſtence varied according to its energy, ought to be well known to the chemiſt, becauſe he muſt perpetually combat and deſtroy it in order to cauſe natural bodies to undergo thoſe changes and modifications which are neceſſary to the reſults he wiſhes to obtain.

In the eighth article, I trace the moſt general and moſt remarkable truths concerning the attraction of compoſition, which chemiſts formerly named *affinity*. To render them more ſtriking and methodical, I have arranged theſe truths as conſtant and invariable phenomena—as the laws which nature has impoſed in the union and the ſeparation of the conſtituent particles of compounds. Habituated during fifteen years to demonſtrate the exiſtence of eight of theſe laws in my lectures and in my elements, I have thought it neceſſary in order to give more development and extent to theſe proofs, that I ſhould add two new laws as general and as important as the eight former. Long experience has ſhewn me that this manner of ſtudying that natural power which effects all the chemical actions of analyſis and ſyntheſis, is much preferable, in the ſimple enunciation of the general facts which characterize it, to thoſe long diſſertations concerning the cauſe and the differences of that force, which only ſhow the imperfection of our knowledge, or tend to miſlead the ſtudent in a labyrinth of facts without order and without connexion.

Since the impreſſion of this work, Citizen Berthollet has communicated to the Inſtitute a long memoir concerning the chemical affinities. He there conſiders the variations to which they are ſubject by changes of the maſs or the different or proportional quantities of the bodies which he cauſes to act on each other. He ſhews that a ſubſtance mixed with a compound has a different action on it, according to the quantity in which it is employed; that when this is augmented, it tends to effect a decompoſition which it could not have produced, if it had been in ſmaller quantity; and that the limits fixed for the effects which take place among bodies ought accordingly to be deſcribed or indicated only from the determinate proportions between the bodies themſelves. Theſe reſearches, though very uſeful in applications of the ſcience to the arts in which it tends to produce conſtant effects, cannot change the principles of that ſcience reſpecting the chemical attractions, becauſe the laws of theſe are explained upon the ſuppoſition of exact, conſtant and well determined quantities as well as temperatures and in circumſtances generally determined.

The ninth article is deſtined to ſhow the exiſtence of the chemical phenomena in nature and in art. As the only aim of chemiſtry, in its ſtudy and its cultivation, is to be of uſe to men, in explaining the ſecrets of natural philoſophy, and teaching how to modify the properties of bodies and render them immediately uſeful to our wants, it was neceſſary to explain that the whole of this ſcience is eſtabliſhed on the profound knowledge of a force which agitates the particles of bodies, by which nature produces great part of her phenomena, and which art, by imitating nature, knows how to put into action to appropriate her productions to our uſes. It was neceſſary to place chemiſtry in the rank which it ought to occupy among the phyſical ſciences, and to aſſign its true department in human knowledge.

The tenth article contains a conciſe definition of the principal operations of chemiſtry. Though this work does not embrace the practice or manipulations of the ſcience, becauſe it is ſolely conſecrated to the explanation of the intire theory, it would have been impoſſible for me to make myſelf underſtood in the deſcriptions of certain experiments which I have here inſerted in many articles, without this preliminary definition. But it is in fact only a kind of nomenclature intended to explain the denominations which it is perpetually neceſſary to uſe in the enunciation of chemical properties. For this reaſon it is that I have compriſed thirty-eight different operations, though it is poſſible to diminiſh this number very much by ſimplifying and generalizing our ideas: however this was not my object.

In the eleventh article, I give the chemical claſſification of bodies, which I have adopted, becauſe, though already enunciated in this diſcourſe, it ought nevertheleſs to form a part of the generalities of chemiſtry, and becauſe it forms the key to the whole connected ſyſtem explained in the work itſelf. This diviſion or claſſification of bodies is treated in the eleventh article of the firſt ſection, rather in a different way, in a more didactic manner, with more preciſion and cloſeneſs than I purpoſe to uſe in this place: it is there connected more intimately with the whole of the work; but in this article it forms an immediate portion of it; being a neceſſary ſequel and an indiſpenſable portion of it.

Laſtly, the twelfth and laſt article terminates the firſt ſection with an account of the principal baſes of the new nomenclature adopted ſince 1787, as well as the new ſigns or characters ſubſtituted inſtead of the ancient hieroglyphics. I have there explained how the preſent names agree with the facts, how they favour and ſimplify the ſtudy of the ſcience by their clearneſs, preciſion, and agreement with the things they are deſigned to expreſs; I have there deſcribed the courſe which has been followed for the eſtabliſhment and formation of that nomenclature, its ſpirit and its principles, without its details or particular terms. I inſiſt on the merit of the language to which it has given birth, and on its importance to the ultimate progreſs of chemiſtry.

NOTICE OF THE SECOND SECTION.

Concerning ſimple or undecompoſed Bodies.

THE ſecond ſection regards the nature and chemical properties of ſimple bodies. It includes, as may be ſeen, the firſt claſs of bodies divided chemically. It anſwers in ſome meaſure to what the ancients named principles or elements, becauſe the ſubſtances which are there examined are not decompoſable, and becauſe they truly form the conſtituent principles of all the compounds.

Theſe bodies are at the ſame time the firſt, the moſt general productions of nature, and the laſt products or extreme terms of the decompoſitions effected by art. As natural productions, they are for the moſt part diſperſed over the globe, and each of them offer a ſort of vaſt reſervoir in which the primitive materials of all compounds are to be found. As the ultimate products of decompoſition, they are the ſubjects which the chemiſt meets at every ſtep which he makes in his courſe of analyſis. In every reſpect, they require to be placed and examined in the firſt rank of the methodical ſeries of bodies.

This ſecond ſection of the chemical ſyſtem, which includes the hiſtory of ſimple bodies, is divided into twelve articles. The firſt contains general conſiderations reſpecting thoſe bodies, their enumeration and their claſſification. I there remark principally that all ſimple or undecompoſed bodies (for the word *ſimple* is taken here only in a relative manner and has in it nothing abſolute,) have immediate relations to combuſtion; that they belong to the hiſtory of that grand phenomenon, as well becauſe they are its products, as becauſe they furniſh its general ſupply, and repreſent its ſubjects. In fact, the greater part of theſe bodies have the combuſtible property; one of them is conſtantly fixed and precipitated on the others, whilſt they burn; another is ſeparated under a double form during that combuſtion, and produces what is univerſally called fire. Thus then the whole ſecond ſection of my ſyſtem of chemiſtry is employed on the phenomenon of combuſtion; ſo that if its title, as well as that of all the following ſections, had not neceſſarily been required in my method to expreſs the nature of the bodies which are there treated, it might be accurately termed *The Hiſtory of Combuſtion.*

After theſe generalities of the firſt article, the eleven following articles contain ſucceſſively the chemical examination of the eleven genera of ſimple bodies; namely, light, caloric, oxigen tinguiſh it from potaſh, with which not half a century ago it was ſtill confounded, namely, its particular form, its great fuſibility, its drying in the air, after its ſtrong deliqueſcence, its leſs attraction for acids, its analogy with animal matters in which it is ſo frequently found combined, and laſtly, the great denſity of the ſaline compounds to which it gives birth.

I ſhall in this place ſtate with rapidity an opinion preſented ſome months ago ſubſequent to the impreſſion of the ſecond volume of my work, concerning the peculiar nature of alkalis and of alkaline earths. Citizen Deſormes, operator of chemiſtry in the polytechnic ſchool, and a very able chemiſt, has thought that he has diſcovered by ſome experiments that hidrogen is the general alkalifying principle; that it is united with lime in potaſh, with magneſia in ſoda, &c. :—but the experiments which he has ſtated are very far from being ſufficient to ſupport his opinion, which indeed he has advanced only as a ſuſpicion. I ſhall obſerve concerning this idea, that I was the firſt who ſuſpected and indicated the preſence of lime in potaſh, and of magneſia in ſoda, and that I do not ſee in the facts announced any reaſon to admit hidrogen any more than azote as the alkalifying principle.

The twelfth article treats of ſtrontian, a baſe diſcovered in 1793 by M. Klaproth of Berlin, which he has conſidered as an earth, and was confounded for ſeveral years with barytes, to which it in effect approaches in many of its properties. I rank it among the alkalis, on account of its energy, its ſolubility, its cryſtallizability, and its attraction for the acids, which follows that of ſoda, and precedes that of lime. I have ſucceſſively preſented the hiſtory of its diſcovery, the methods of obtaining it pure from two of its natural compounds, its phyſical characters and chemical action on all the bodies placed before it in my claſſification. I have ſhown the characters which diſtinguiſh it from barytes, its leſs ſpecific gravity, its weaker ſolubility, its form and that of its compounds, its attractions, its phoſphoreſcence, the purple colour which it gives to flame when it is held in ſolution, its inaction, or its effect, at leaſt not poiſonous to living animals, in compariſon to the deſtructive action of barytes. With regard to theſe two baſes, which appear to be confounded or only to differ from each other by certain ſhades in their properties, I have deſcribed the particular art of obtaining them in a ſtate of purity and of cauſticity which was long unknown to chemiſts, and which conſiſts, according to the diſcovery of Citizen Vauquelin, in the complete decompoſition of each of their nitrates by heat in cloſed veſſels.

Ammonia occupies the thirteenth article. This ſpecies of alkali, long deſcribed by the name of volatile alkali, ſo eminently diſtinguiſhed, by its odour and its eaſy converſion into vapour, from the two alkalis which were formerly named fixed, is ſuſceptible of aſſuming the two ſtates, gaſeous and liquid, and of permitting the ſeparation of its two conſtituent principles by the reaction of many burned bodies, as well as to form itſelf by the union of azote and of hidrogen, according to the beautiful diſcoveries of Scheele, Bergmann, and principally of Citizen Berthollet. Its hiſtory requires many more details than that of the other four alkalis, to which analyſis and ſyntheſis are ſtill equally wanting. I ſucceſſively examine ammoniacal gas, and ammonia properly ſo called, or in the liquid ſtate, as to their phyſical and chemical properties, in their different combinations with the ſimple and burned bodies, in their artificial decompoſition and formation. By inſiſting on the abundance of azote in this ammoniacal compound, and on its eaſy decompoſition as well as compoſition, I have ſhown how this knowledge acquired in our own time, concerning the nature of this alkali, the only one at preſent well determined as to its principles, throws light on a great number of chemical phenomena; particularly with relation to the ammoniacal ſalts, to animal matters, and to their decompoſition by heat and by putrefaction. In a word, I give to this article all the extent and the importance which this ſpecies of body requires, which it is intended to explain. It is one of thoſe in which will be found, on peruſing it with the attention it deſerves, the moſt marked difference between the preſent and the former ſtate of chemiſtry; it is, in fact, one of the neweſt and moſt uſeful in the whole work, for conveying information reſpecting the ſcience. I muſt here add that, after drawing up that article, Citizen Vauquelin and myſelf had occaſion to obſerve in liquid ammonia the property of coagulating, of freezing, and even of cryſtallizing in long aggregates of priſms, or of brilliant and ſatin-like needles with ſix ſides, when it is expoſed to a temperature of 28 or 30 degrees beneath the 0 of the thermomerer of Reaumur. At that temperature, indeed, many bodies which it has not hitherto been poſſible to obtain in the ſolid form, are capable of aſſuming one more or leſs regular.

The fourteenth and laſt article of the fourth ſection is the moſt extenſive of any; it contains general notions of lithology or the hiſtory of ſtones, which I place after the ſalifiable baſes, becauſe they are truly to the chemiſt natural combinations of earths with each other, or of certain earths with potaſh. Theſe bodies are a part of the ſixth claſs of my general and chemical diviſion of the productions of nature; the reſt of that claſs will be given in ſeveral other of the following ſections: this is placed in the ſequel of the earths, on account of the nature or the particular order of compoſition which conſtitutes the ſtones. The ſcience is not yet ſufficiently advanced, and the analyſis of ſolid, earthy compounds, or of ſtones is not ſufficiently complete, to enable me to preſent a methodical and chemical diviſion of theſe bodies, as I could have wiſhed. To remedy this defect, I have thought it neceſſary to give at leaſt an abridgment of the actual diſcoveries on lithology, and, to do this methodically, I have divided this article into ſix paragraphs.

In SECTION the FIRST, are explained the diſtinctive characters of ſtones, taken

A. From their phyſical properties, ſuch as weight, hardneſs, tranſparency, double or ſimple refraction, electricity, magnetiſm, colour, taſte and odour.

B. From their geometrical properties, or their external and internal form, from thoſe of their integrant parts or molecules, and from their fractures.

C. From their chemical properties; namely, from the action of heat alone; from the action of heat aided by different fluxes, and from that of the acids. In this ſketch, I have omitted none of the properties which are conſidered in ſtones, to eſtabliſh eſſential diſtinctions between them, nor any of the principal ſhades which each of theſe properties preſent to the obſerver; I have availed myſelf of all the data collected by modern mineralogiſts.

In SECTION the SECOND, I have given an outline of the principal methods of lithology, founded on the external and ſenſible properties, or on the methodical uſe which lithologiſts have made of theſe properties, compared or contraſted with each other, to diſpoſe the ſtones with regularity, and to diſtinguiſh them from each other. I have ſucceſſively ſpoken of the attempts made in this way by Bromel, Cramer, Henckel, Wolſterdoff, Gellert, Cartheuſer, Juſti, Lehman, Vogel, Scopoli, and principally by Wallerius, Romé-Deliſle, Werner and Daubenton. But I have ſhown their inevitable defects, their inſufficiency to afford a real know- of ſtones, and their merit, which conſiſts merely in the art of diſcovering the name which has been given to each of theſe bodies in particular.

In SECTION the THIRD, I have preſented a ſhort notice of the lithological ſyſtems, founded on the chemical nature or compoſition of ſtones, from Cronſtedt who firſt adopted that happy idea, to Bergmann, de Born, and the celebrated M. Kirwan, the laſt who has written a ſyſtematic work on this part of the natural ſciences. By comparing theſe ſyſtems with the phyſical or external methods, I have ſhown that, however complete they may be capable of becoming, they will never intirely diſplace the latter, which will always be required to diſtinguiſh ſtones from their aſpect without deſtroying their texture.

SECTION the FOURTH, preſents the ſequel of the ſtones, treated according to the plan adopted by the French mineralogiſts, according to the lateſt enquiries of Citizen Haüy. As there are only forty-five natural ſubſtances truly ſtony, by excluding from that claſs all the foſſils, formerly reckoned among the ſtones, but which belong to the ſalts or acidiferous ſubſtances, or to ores, this celebrated French mineralogiſt has thought it unneceſſary in order to the deſcribing and explaining them with care, to divide them into genera, or to eſtabliſh numerous diſtinctions and characters between them, but only to arrange them in a ſeries moſt proper to indicate their relations and their differences. The greater part of theſe forty-five ſtones have new names taken from their moſt ſtriking properties, and imagined by Citizen Haüy. I have given, after him, an abſtract of their characters and of their differences, by quoting, under as many of the ſucceſſive members, quartz, ſilex, zircon, teleſia, cymophane, ruby, topaz, emerald, euclaſe, grenate, leucite, idocraſe, feldt ſpar, petro-ſilex, coryndon, ceylanite, axinite, tourmaline, amphibole, actinote, pyroxene, ſtaurotide, thallite, ſmaragdite, oiſanite, dioptaſe, lazulite, zeolite, ſtilbite, prehnite, chabaſia, analcime, ſommite, andreolite, peridot, mica, cyanite, tremolite, leucolite, dipyre, aſbeſtos, talc, chlorite, macle, and argil. I add to their phyſical properties whatever is known concerning their nature and their compoſition.

SECTION the FIFTH, is employed in a deſcription of the method of analyſis which the modern chemiſts have adopted for ſtones, and of the proceſſes which they practice to ſeparate their different conſtituent parts, as well as to eſtimate their proportions with accuracy. They conſiſt in grinding the ſtone with water in a mortar of ſilex, and fuſing it in a crucible of ſilver, with three times its weight of pure ſolid potaſh prepared by alcohol; then diluting it with a ſufficient quantity of water; adding muriatic acid ſufficient to diſſolve all the fuſed maſs; then treating in the ſame manner that portion of the ſtone which, having reſiſted the alkali, has not been diſſolved in the acid; by evaporating the ſolution to dryneſs in a veſſel of platina or of porcelain; then adding a little muriatic acid towards the end; diſſolving this maſs in water; by igniting and weighing the ſilex which falls down and is not rediſſolved in the laſt liquid; by precipitating by alkaline carbonates, the other earths, which remain diſſolved in the ſtate of muriates; by treating the precipitate by a ley of potaſh to rediſſolve the alumine, which is afterwards ſeparated by an acid or by a carbonate, to ignite this by calcination in a crucible; to diſſolve the other earths by the muriatic acid; to precipitate the lime, magneſia, and the oxide of iron, if preſent by a ſolution of cauſtic potaſh and afterwards the barytes by ſulphuric acid. The proper methods of ſeparating the lime, magneſia, oxide of iron, and thoſe of diſcovering zircon, glucine and potaſh, are afterwards deſcribed with ſufficient detail to remove every difficulty on the ſubject.

Laſtly, in SECTION the SIXTH: I have given the reſult of all the analyſes of known ſtones, by announcing the varieties of each ſpecies, diſtinguiſhed by a number correſponding to that which it occupies in the ſeries, from No. 1 to No. 45, by placing together the analyſis made by different chemiſts, principally by Margraff, Bergmann, Klaproth, Vauquelin, Wiegleb, Kirwan, Pelletier, Sauſſure, Gmelin, Bindheim, Achard, Weſtrumb, Scopoli, Fabroni, Morell, Mayer, Struve, Hoepfner, Huzer, and Collet-Deſcotils. Theſe are the philoſophers who have occupied themſelves moſt in this kind of lithological analyſis.

The four firſt ſections of which I have now given an account, compoſe volumes I. and II. of the edition in 8vo. and the 1ſt volume of the edition in 4to.

NOTICE OF THE FIFTH SECTION.

Concerning the Salts.

THE fifth ſection, devoted to the chemical hiſtory of the ſalts, or compounds formed by the union of the acids, and of the baſes, is one of the moſt extenſive and, at the ſame time, one of the moſt new. Since the year 1782 I had already given in the different editions of my Elements of Chemiſtry, a much more extenſive detail concerning ſaline matters than any author had before given reſpecting theſe objects, either in French works, or in thoſe of other countries which have come to my knowledge. The number of the diſcoveries made a ſhort time before that period concerning the acids and certain earthy baſes, enabled me to give to that part of the ſcience a development till then unknown. For ſome years before 1778, till which time my ſtudies were continued under the moſt able profeſſors of chemiſtry in Paris, it was not uſual to diſtinguiſh more than twenty ſaline matters at moſt: It was cuſtomary to aſſociate them with the hiſtory of each of the acids, of which they were regarded as compounds inſeparable in the explanation of their properties. By following in this reſpect the ſyſtem of my maſter, Bucquet, who firſt diſtinguiſhed the ſalts and has claſſed them methodically in his introduction to the ſtudy of the mineral kingdom, I greatly extended that claſs, and I enriched it, in 1782, with all the diſcoveries made ſince the death of that illuſtrious profeſſor, whoſe method and perſpicuity were my firſt guides. In the three following editions of my Elements of Chemiſtry, I have ſucceſſively augmented the ſeries of its compounds. But ſince 1791, the period of the fourth edition of that work, how numerous are the facts added to thoſe formerly known, and tending to modify the whole of our reſults!

Two earthy baſes have been diſcovered, zircon and glucine: one ſubſtance which was at firſt thought to be an earth, namely, ſtrontian, has been added to the alkaline baſes. The ſaline combinations of the phoſphoreous and ſulphureous acids have been examined. The ſulphites and the phoſphites, then only announced, have been examined with ſufficient care; the exiſtence of the nitrites has been aſcertained. The ſuper-oxigenated alkaline and earthy muriates have been diſcovered. A more exact analyſis of many foſſils has cauſed ſubjects to be ranked in the claſs of ſalts which were before regarded as ſtones. The ſucceſſive labours of the moſt able chemiſts of Europe have thrown new light on a very great number of ſalts which were not known before, or which were only known inaccurately, particularly on theſe which have an exceſs of their baſes of their acids or which have double baſes or thoſe which are named triple ſalts. The general reſult of theſe modern reſearches carries the number of ſalts, limited, twenty years ago, to thirty or more, up to a hundred and thirty-four ſpecies.

Occupied myſelf with a part of theſe inquiries, and a witneſs of the diſcoveries to which they have conducted my friends and aſſociates, Guyton, Pelletier, Berthollet, and Vauquelin, with regard to the greater number of the ſalts; obliged particularly by my duty to communicate them every year to a great number of pupils, I have ſeen that the difficulties with which the ſtudy is already ſurrounded, would continually increaſe, if an uſeful and clear method were not adopted to enlighten and direct their ſteps. By long meditation on this ſubject, from numerous experiments made during ſeveral years of ſtudy I have at length been enabled to adopt an order, a claſſification which render the ſtudy and the exact knowledge of theſe ſubjects infinitely more eaſy. In eſtabliſhing this claſſification, my aim has been to attach in ſome meaſure to the mere relative diſpoſition of the hundred and thirty-four ſpecies of ſaline compounds, the moſt eſſential part of their diſtinctive properties; to repreſent the principal characters deſtined to diſtinguiſh them from each other merely by their mutual ſituation; in a word, to render the method itſelf ſubſervient to the expoſition of the moſt ſtriking facts in their hiſtory. Such is, without doubt, the moſt prominent advantage and, at the ſame time, the moſt original part of this fifth ſection, the regular order of which allows me to point it out as one of the moſt important portions of my whole work.

All the ſaline matters, of which it contains the chemical examination, are divided into genera and ſpecies. The firſt, founded on the acids, and bearing each the name which characterizes theſe laſt, according to the principles of the methodical nomenclature, are arranged or diſpoſed in the order of the attractive force of the acids for the baſes in general: in ſuch a manner that the ſulphates are the firſt of theſe genera, and the carbonates the laſt, becauſe the ſulphuric acid moſt ſtrongly attracts the alkalis and earths, whilſt the carbonic acid attracts them leaſt. So that this diſpoſition of the genera already ſhews by what acids and in what order of attraction the genera of ſalts are reſpectively decompoſable.

In each genus, the ſpecies are arranged according to the ſame order of attraction, by following in this place the attraction of the particular baſes for the acid of each genus. Thus, among the ſulphates, or in the firſt genus, the ſulphate of barytes is the firſt ſpecies, becauſe barytes adheres more to the ſulphuric acid than all the baſes which it is capable of ſeparating from it; the ſulphate of zircon is the laſt ſpecies, becauſe the zircon is the leaſt adherent of all the baſes, and may be precipitated from it by all the others. Between theſe two ſpecies are ſucceſſively placed the ſulphates of potaſh, of ſoda, of ſtrontian, of lime, of ammonia, of magneſia, of glucine and of alumine, becauſe this is the order of the attractions which govern the adherence between all the baſes and the ſulphuric acid. It may be conceived, after this ſimple expoſition, that the ſeries of ſalts ſo diſpoſed, form a table, which repreſents, after the faithful order of the attractions of their principles, their principal properties of decompoſition.

If to this order, or arrangement by the attractions, intended to explain the principal properties of the ſalts, we add the very ſignificant names which they all bear, and which give a preciſe notion of their nature, at the ſame time that they diſmiſs for ever the arbitrary denominations which were formerly given to them; if it be conſidered, that in addition to this regular progreſs each genus is firſt treated under the relation of its generic characters, proper to diſtinguiſh it from all the others, and each ſpecies examined afterwards as to all the properties which characterize it, it will be perceived that this hiſtory of the ſalts, which occupies the third and fourth volumes in octavo or the ſecond volumes in quarto, is very different from whatever has been hitherto publiſhed in chemiſtry.

I muſt now point out the diviſion and ſubject of the different articles which compoſe this fifth ſection of my work. It is divided into eighteen articles. The firſt is devoted to generalities, to the claſſification of the ſalts, and to the expoſition of the manner in which I have treated them. With the general principles which I have juſt traced, I ſpeak in detail concerning the rules of nomenclature, which are of importance to be well known, becauſe they truly direct the preciſe knowledge which it is neceſſary to acquire. I indicate the manner in which I then divide all the following articles appropriated to each genus of ſalts.

The II, III, IV, V, VI, VII, VIII, IX, X, XI, and XIIth have for their ſubject the eleven genera of ſalts which I diſtinguiſh; namely, the ſulphates, and the ſulphites, placed in the ſecond rank as dependants of the ſulphates; the nitrates, and the nitrites, coming as dependant on the nitrates; the muriates, the oxigenated muriates, the phoſphates, the phoſphites, the fluates, the borates and the carbonates. Each of theſe articles is divided into two paragraphs: the firſt, intended to explain the generic properties or the hiſtory of the genus; the ſecond, having for its object the particular hiſtory of all the ſpecies which belong to that genus. In the firſt, I treat of the chemical properties which characterize without exception all the ſpecies compriſed in the genus; in the ſecond, in treating each ſeparate ſpecies in the order of its attraction of the baſe for the acid, I conſtantly follow the ſame method, and I conſider, under the eight letters which precede the under titles, A. the ſynonymy and hiſtory of the ſpecies; B. its phyſical properties; C. its natural hiſtory and preparation; D. the action which it experiences on the part of caloric; E. on that of water; F. its relations with water; G. its decompoſition, the agents which effect it, and the proportion of its principles; H. laſtly, its uſes. Long experience has proved to me that it is poſſible to include under theſe eight diviſions every thing that any ſpecies of ſaline ſubſtance preſents of intereſting or uſeful to be known. By the aſſiſtance of this identical proceeding, I have needed fewer details than would have been neceſſary without it, to deſcribe and accurately to explain the hundred and thirty-four ſpecies of ſalts of which this claſs of bodies is at preſent compoſed.

In the thirteenth article, I have preſented a ſummary of the principal properties of ſaline bodies compared with each other, to recapitulate the different characters of which they are ſuſceptible, and to exhibit an whole calculated to leave preciſe ideas reſpecting the manner of ſtudying their properties. Five paragraphs which ſucceſſively compoſe that article treat of their taſte, their cryſtalline form, their fuſibility or the action of heat on them, and the action of air and of water. Then paſs ſucceſſively in review their acridneſs, bitterneſs, ſtypticity, ſweetneſs, flatneſs, coolneſs, inſipidity, earthy taſte; their figures cubical, rhomboidal, octahedral, priſmatic, pyramidal; their aqueous and igneous fuſion, calcination, volatilization, partial or total decompoſition; deliqueſcence, efloreſcence, change or unchangeableneſs by the contact of the atmoſpheric; laſtly, the different modes of ſolubility in cold and hot water.

The fourteenth article affords another kind of ſummary, preſenting in a table, the hundred and thirty-four ſalts, diſpoſed according to the indicated method, and diſtinguiſhed from each other by the ſpecific characters belonging excluſively to each ſpecies. It is an eſſay of the Linnæan method, applied to this part of chemical knowledge, and intended to repreſent, under a new form, a rapid expoſition of the ſaline ſpecies, each characterized by an excluſive property. In this eſſay, I have adopted the means of ſtill preſenting the ſeries of ſalts, concerning which it is ſo important to acquire accurate notions. The poſſibility of diſtinguiſhing the numerous ſpecies from each other by a ſingle character, is here ſeen, while their generic character is alſo well determined, and their diſpoſition with regard to the elective attraction of the baſes is equally well aſcertained.

With the ſame invariable view of rendering the hiſtory of ſaline ſubſtances more complete, and in ſome reſpect more intire, I have included in the fifteenth article, an enumeration of the double decompoſitions which mutually take place between the hundred and thirty-four ſpecies of theſe ſubſtances. This enumeration, though long upon the whole, is highly valuable in its details, on account of the form which I have given it, and ſhews that the number of well known double decompoſitions is already much more conſiderable than it was before the modern diſcoveries. I do indeed comprehend in that liſt thoſe alſo which I only ſuſpect; but ſetting theſe aſide, it will be ſeen that there are ſtill near a thouſand which are determined with ſufficient accuracy. It is not with a view to engage ſtudents to commit this long ſeries of chemical facts to memory, and to compel them, by an uſeleſs fatigue, to retain them, that I offer this enumeration, of which no chemical work has yet preſented the like, but only that thoſe who wiſh to penetrate the depths of the ſcience, and to contribute to its improvement by their own reſearches, may be able to diſcover the defects, or to determine theſe ſaline attractions, or even the more or leſs probable ſuppoſition of their exiſtence. In order that an enumeration of this kind ſhould acquire that certainty to which I ſhould have greatly wiſhed to carry it, many more experiments are neceſſary, and particularly ſuch as are more accurate than have yet been made concerning them. Further reſearches will gradually correct their defects, ſupply their vacancies, rectify their progreſs, and more eſpecially afford the means of generalizing our conceptions of theſe bodies; an ultimate object which it was not permitted me to carry into effect, though I have been well aware of its importance and have even attempted the execution by exertions equally laborious and unavailing.

In the ſixteenth article I have conſtructed a table of the compoſition of all the ſpecies of ſalts and of the proportion of the principles which form them. Though the enunciation of their compoſition conſtituted one of the points of their detailed hiſtory in the preceding articles, where it is pointed out with accuracy, I have thought it neceſſary to re-trace it again, in order that the ſeveral relative quantities of acids and of baſes united in theſe compounds, might be compriſed, and certain general reſults deduced concerning the laws and the points of ſaturation. But I have not preſented theſe reſults, becauſe I know that the proportions are not yet without ſome error; and that this part of the ſcience, the moſt difficult of all, is ſtill far diſtant from the preciſion and the certainty to which it will hereafter arrive, notwithſtanding the ability, the talent and the accuracy of the modern chemiſts who have begun to employ themſelves upon it. Some notion may be formed of this from the diverſity of reſults which many of the moſt celebrated philoſophers among thoſe, who have laboured on this ſubject, have obtained in their analyſes. This table, though imperfect, will nevertheleſs afford great advantages to chemiſts. It would be no ſmall advantage, even if it produced no other than that of convincing them of the neceſſity of new reſearches concerning this great object, and of bringing the methods of ſaline analyſis to perfection, which, in many reſpects, are ſtill incumbered with difficulties almoſt inſurmountable.

The ſeventeenth article is a recapitulation of the ſalts which exiſt in the foſſil ſtate, and of the manner in which they have been claſſed in mineralogical methods or ſyſtems. I have ſhewn that with regard to the ſmall number of ſalts known in mineralogy, it is not neceſſary to eſtabliſh any diviſions or claſſifications different from thoſe of the chemiſts; that thoſe, and in particular that which I have adopted, intirely anſwer the object of mineralogiſts, and that therefore it is quite ſuperfluous to adopt the particular denomination of acideferous ſubſtances to deſignate theſe natural compounds. To prove this aſſertion I compare the mineralogical and chemical diviſions, and make various reflections to explain the utility of the combination of the two methods in one, founded on the chemical nature of natural ſaline ſubſtances. Beſides which, the ſucceſſive diſcoveries there is reaſon to expect from the chemiſts occupied in the examination of foſſils, will neceſſarily produce that union, and will cauſe mineralogy to be conſidered ſimply as a branch of chemiſtry, as I have already diſtinguiſhed it under the name of *mineral* or *mineralogical chemiſtry.*

Laſtly, in the eighteenth and laſt article of the fifth ſection, I treat of the ſalts which are found in ſolution in earthy waters, and conſequently of the analyſis of mineral waters. This has always been conſidered as one of the moſt difficult parts of chemiſtry, as well on account of the ſmall quantity of the ſeveral ſubſtances diſſolved, as on account of the number of the ſalts which exiſt at the ſame time in theſe waters, and produce complicated effects by mutual re-action, or by their operation with the different re-agents I have therefore ſpared no pains to give to this article, however conciſe, a degree of perſpicuity which muſt conſtitute its principal merit: I have made a ſummary of the greater number of the facts contained in the preceding part of my work: I have divided it into a number of paragraphs which begin with the hiſtory of this kind of analyſis, and conclude with the preparation of artificial mineral waters, or the imitation of thoſe which nature preſents to man. It was even neceſſary that I ſhould treat of the preſence of certain metallic compounds, though the properties of theſe belong in ſtrictneſs to the following ſection; but I have done this in a very conciſe manner.

It muſt be ſeen, from this expoſition, how much more extenſive and accurate the hiſtory of ſaline matters is here given than it has been ſtated in any other work of chemiſtry, and more particularly that the method adopted in this ſection is very different from what has hitherto been followed.

Since the impreſſion, two diſcoveries of great importance have been made in the hiſtory of the ſubſtances of that order. One relates to the exiſtence of a fluate of alumine in nature. M. Abildgaard, of Copenhagen, has ſent to Citizen Vauquelin, among other foſſils, a pretended ſtone of Greenland, which he has diſcovered by analyſis to be a combination of fluoric acid and alumine. Citizen Vauquelin has confirmed that diſcovery by a new examination of that foſſil.

The other diſcovery has for its object a compound ſalt of ſulphate of ſoda and of hidroſulphuret with the ſame baſe, that is to ſay, a true hidro-ſulphurated ſulphite of ſoda, produced by the decompoſition of ſulphate of ſoda by charcoal, made on a large ſcale in a manufactory near Paris, for obtaining ſoda. Citizen Chauſſier, who has employed this compound with ſucceſs in many diſeaſes of the lymph, ſuppoſed it to be a ſimple hidro-ſulphuret of ſoda. But Citizens Vauquelin and Thenars, who have examined it with great care, have found it to contain ſulphureous acid, ſoda, ſulphurated hidrogen, and they have beſides obtained a ſalt intirely ſimilar in its form, its taſte, its ſolubility, and all its other properties, by mixing a ſolution of hidro-ſulphuret of ſoda, with a ſolution of ſulphite of ſoda. At the very moment of the union of theſe two liquids, the firſt, which is of a deep yellow colour, becomes immediately colourleſs.

The firſt of theſe diſcoveries confirms what I have long ago announced, that in proportion as foſſils are examined, all the ſalts which art can fabricate will be found; and the ſecond may lead us to the knowledge of new compounds, by ſhewing the intimate union of an alkaline hidro-ſulphuret with a ſalt of the ſame baſe.

NOTICE

NOTICE OF THE SIXTH SECTION.

Concerning the Metals.

I HAVE already remarked, on various occaſions, that the metals, though compriſed on account of their ſimple and undecompoſed nature in the firſt claſs of bodies, and conſequently in the ſecond ſection of this work, preſent nevertheleſs ſo many important properties, and have ſo much influence on the theory and the practice of the ſcience, as well as on thoſe of the arts, that it is neceſſary to ſtudy them with much care, and to give to their hiſtory all the extent and fulneſs of which they may be ſuſceptible. Accordingly they have been only indicated in the ſection of undecompoſed bodies, to compare them with hidrogen, carbon, phoſphorus and ſulphur: and I have obſerved that their properties could not be deſcribed but ſubſequent to thoſe of the acids, of the baſes and of the ſalts which ſerve to explain them. For this reaſon, this ſixth ſection of my work is devoted to them in particular. The multiplied forms which theſe bodies have received from nature, the numerous combinations which art has learned to give to them, the almoſt infinite uſes to which human induſtry has applied them, moſt of which are directed by the efforts of the chemiſts, render this part of my chemical ſyſtem one of the richeſt in facts, in reſults, and one of the moſt extenſive in its details. It is neceſſary to add to theſe firſt conſiderations, that the hiſtory of the metals perpetually exhibits them as having a great influence on all the diſcoveries of chemiſtry; that in all the revolutions of the ſcience, they afford facts of the greateſt importance; that they are in ſome inſtances applied as inſtruments, in others as new products to all the periods of the advancement of human knowledge; that from their conſtant influence on the progreſs of reaſon, they occupy a diſtinguiſhed place in the annals of natural philoſophy; and that thus, in every reſpect, there is no production in nature which deſerves more profound attention, more conſtant ſtudy, or more exact deſcription than the metals.

The whole of the ſixth ſection, which treats of metals in particular, is divided into twenty-two articles: the firſt including generalities concerning theſe bodies, and the twenty-one following, comprehending the particular hiſtory of each of the metallic ſubſtances, of which the ſpecies known at preſent amount in effect to that number.

To give a proper account of theſe combuſtible bodies, I have thought it neceſſary to explain firſt the baſes and the principles of the characters which diſtinguiſh them from other bodies, and the various proceſſes by which chemiſts have diſcovered them. I have been deſirous of treating theſe generalities ſo fully as to leave nothing obſcure or uncertain, in order to compriſe whatever is known concerning the different ſtates, and the different compoſitions of which the metals are ſuſceptible. With this intention, I have divided the firſt article into twelve paragraphs.

The firſt paragraph treats of their importance and of their literary hiſtory.

The ſecond, of the number and the claſſification of the metals. I here divide them into five genera, according to their various ductility and oxidability: the firſt genus comprehends brittle and acidifiable metals; namely, arſenic, tungſten, molybdena, and chrome; the ſecond, the brittle and merely oxidable metals, to the number of eight ſpecies, titanium, uranium, cobalt, nickel, manganeſe, biſmuth, antimony, and tellurium; the third, the ſemi-ductile metals, mercury and zinc; the fourth, the ductile and eaſily oxidable metals, tin, lead, iron, and copper; and laſtly, the fifth genus, the very ductile and difficultly oxidable metals, in number three, ſilver, gold, and platina. Before I explain my new diviſion, I ſhow the errors of the ancient methods which divided them into ſemi-metals, imperfect metals, and perfect metals.

The third paragraph of the firſt article contains a general examination of the phyſical properties of metals. They are ſucceſſively compared with each other, 1ſt, as to brilliancy, 2d, colour, 3d, denſity or weight, 4th, hardneſs, 5th, elaſticity, 7th, tenacity, 8th, conductibility of caloric, 9th, dilatability, 10th, fuſibility, 11th, volatility, 12th, cryſtallizability, 13th, electricity, 14th, odour, 15th, laſtly, taſte. In the examination of each of theſe properties, I have taken particular care to preſent the order in which the metals may be diſpoſed relatively to the degree or intenſity of each of each property.

In the fourth paragraph, I treat of the natural hiſtory of the metals; I indicate the five ſtates in which they are found in the interior of the globe; namely, 1ſt, that of native metals; 2d, that of alloys or of ſeveral metals united in the metallic ſtate; 3d, the ſulphureous ores, or compounds of metals and of combuſtible bodies; 4th, the oxides of metals; 5th, the metallic ſalts, or combinations of their oxides with ſeveral acids. I enlarge on mineralization and the different mineralizers.

The fifth paragraph treats of the art of aſſaying the ores, or of docimaſy in general. As this object comes in detail under the hiſtory of each metal, I have given only certain generalities or the moſt important facts in this art which is entirely chemical. I there, however, indicate the difference which exiſts between the ordinary or common aſſay of the miner, whoſe only aim is to diſcover the metal which may be obtained from an ore, and the facility or the difficulty with which its extraction is accompanied; from the docimaſtic analyſis of the chemiſts, who, having for their object to determine the nature and the proportion of different mineralizers, the proportion and the ſtate of the mineralized metals, demands a great number of facts, many reſources, and great ability in thoſe who ſtudy them. The moderns have greatly improved this branch of the art.

The ſixth paragraph conſiders the ſame generalities, relatively to metallurgy or working of ores in the large way for their extraction from the earth, ſorting, ſtamping, waſhing, roaſting, fuſing, and refining the metals. I give only the moſt general principles of the art of treating the ores; which is treated rather more fully under the article of each of the metals.

The ſeventh paragraph commences the examination of their chemical properties in the oxidability or combuſtibility of the metals by the contact of the air. I there announce the rapid inflammability of ſome of them, the ſlow deſtruction of others, the different phenomena they exhibit during oxidation, the different kinds of oxidation they are capable of undergoing, the various temperatures at which they burn, their oxides differing by their ſtate and by the proportion of oxigen which they contain, the attraction which that principle exerciſes on the metals, and the characters which ſerve to diſtinguiſh the different oxides of the metals or the different oxides of the ſame metal.

In the eighth paragraph, I rapidly deſcribe the combinations of which the metals are ſuſceptible with the ſimple combuſtibles, hidrogen, carbon, phoſphorus, ſulphur, the diamond, as well as thoſe which they form among each other. I give only a ſlight ſketch becauſe the object is treated much more fully under the article of each of the metals.

The ninth paragraph explains the ſeveral actions of the metals in general on water and the oxides. I divide theſe bodies into four claſſes with regard to their action on the oxide of hidrogen: the firſt decompoſes it in the cold; the ſecond only by heat; thoſe of the third ſtand in need of another body, of oxides, or of alkalis, to effect that decompoſition; and thoſe of the fourth cannot even produce it with the aid of theſe laſt bodies. The action of the metals and of their proper oxides is indicated afterwards with the ſame rapidity.

The tenth paragraph explains the general reactions which take place between the metals and the acids. Though briefly announced and only preſented as a ſlight ſketch, this reaction, nevertheleſs, ſhows the different modes of alteration which theſe bodies are capable of aſſuming by their contact: I have ſtated that the metals cannot be combined with the acids without being previouſly oxided; that this oxidation takes place, in ſome caſes, from the action of the acids and, in others, from the action of the water, and ſometimes from both; that the metals adhere to the acids in a determinate degree of their proper oxidation, above or beneath which all combination is prevented or deſtroyed. I point out the moſt general properties of the metallic ſalts, and I always take care to refer their properties to ſome leading terms, founded in general on the different attraction of the metals for oxigen, and of the different metallic oxides for the acids. Laſtly, I reſume each of the ſeveral acids already known, in order to deſcribe the mode of alteration which it undergoes on the part of the metals, and what they themſelves receive from it.

The eleventh and twelfth paragraphs terminate the generalities concerning the chemical properties of the metals by a ſhort indication of the effect theſe bodies experience on the part of the ſalifiable baſes and the ſalts. I there reduce, as in the preceding paragraphs, theſe effects to certain general titles, in order to exhibit a view of all the kinds of alteration which the earths, the alkalis, and their ſaline compounds effect in the pure or oxidated metallic ſubſtances, as well as the changes they receive from them.

All theſe generalities, which compoſe the firſt article, are intended to render it more eaſy to underſtand, and conſequently to abridge whatever is delivered in the following twenty-one articles, concerning metallic ſubſtances in particular.

The ſecond article, including the chemical examination of arſenic and its acids, is divided into two paragraphs, becauſe that brittle and very combuſtible metal comes under our obſervation in its three forms of metal, of arſenious acid, and of arſenic acid;—ſtates ſo varied that it is of importance to know them. In the ſtate of metal I conſider ſucceſſively, A. its hiſtory; B. its phyſical properties; C. its natural hiſtory; D. the docimaſtic and metallurgic operations to which it is ſubmitted; E. its oxidability by the air; F. its union with combuſtible bodies; G. its action on water, and on the oxides; H. its action on the acids, and their action upon it: I. the effects which it is ſubject to on the part of the baſes and of the ſalts; laſtly, K. its uſes. Theſe ten under-titles comprehend all the chemical facts which can be diſcovered reſpecting this metal.

In the ſecond paragraph, are treated the two acids which arſenic forms in its two laſt ſtates of combuſtion. I call that the arſenious acid which was formerly called oxide of arſenic, becauſe this pretended oxide preſents in effect all the properties of the weak acids; it converts turnſole to a red; it has a very ſtrong acrid taſte; it is ſoluble in water; it unites with the alkalis; it decompoſes the ſulphurets; in a word, it is to the arſenic acid what the ſulphureous is to the ſulphuric, &c.

The third, fourth, and fifth articles preſent, under the ſame diviſions into two paragraphs, the tungſtenous and the tungſtic acid, the molybdenous and the molybdic acid, the chromous and the chromic acid. I have inſiſted with regard to the firſt on the attraction of its oxide to the colouring matters; in the ſecond, on its reſemblances and its differences compared with the carburet of iron, and, in the third, on the different ſtates in which it has hitherto been found in nature, on the diſcoveries which have originated from the new and intereſting acidifiable metal for which we are indebted to the reſearches of Citizen Vauquelin, in Frimaire of the ſixth year (December 1797). The name of this laſt body, derived from its colouring property, announces what the arts may one day hope from its uſe. Though theſe three metals are not ſo well known as arſenic and the greater part of the ſeventeen following, I have conſtantly proceeded in their hiſtory, according to the ten under titles which were uſed for arſenic.

I have followed the ſame method preciſely in the ſeventeen articles which follow the fifth. I have always regulated their examination by the ſame ten under-titles, in order that the hiſtory of all theſe metals might be ſubjected to one method, and be comparable in every point. I ſhall, therefore, confine myſelf in this place to give an account of the work which relates to them, and to announce each of theſe metals, in the order of their ſucceſſive deſcription.

Titanium, the object of the ſixth article, is a brittle metal very new to chemiſts. It was diſcovered in the 3d year (1795) by M. Klaproth of Berlin, and exiſts in ſufficient abundance in France, particularly at St. Yrieix, in the department of Haute-Vienne, under the form of what is named red ſchorl, or its oxide; it is conſidered as to its docimaſtic reduction, its various combinations, whether in the metallic ſtate, which is difficult to obtain on account of its difficult fuſibility, in the ſtate of oxide, or in that of carbonate, with combuſtible bodies, water and the oxides, the acids, the baſes, and the ſalts. The very long details which concern it, relate to its ſaline compounds, to its oxidation which takes place in a great number of caſes, and to its uſes for porcelain, enamels, &c.

Uranium, the ſubject of the ſeventh article, another diſcovery of M. Klaproth, made in 1789, is little known, and ſcarcely can be ſaid to exiſt in France, becauſe it is but lately that it was found in that Republic, near Autun, by Citizen Champeaux, engineer of mines. It has demanded very long details concerning its hiſtory, its different ſtates in nature, and its different properties which have been diſcovered in Germany, where only it has hitherto been examined. It is almoſt entirely unknown under the metallic form, becauſe extremely difficult to obtain; it has ſcarcely been treated but under the form of oxide; its uſes are yet unknown,

known, becauſe it is exceſſively rare, and, as it ſhould ſeem, not very abundant. It appears capable of forming a brilliant orange-colour glaze for porcelain.

Cobalt, deſcribed in the eighth article, of which the greater number of chemiſts at preſent acknowledge the exiſtence as a particular metal, is treated much more at large than the two preceding, becauſe it has been much longer known, and becauſe it has been the ſubject of a very great number of reſearches. I have more eſpecially inſiſted on its differences from the other brittle metals, on the art of purifying it, on its true ores, its combinations with the acids, the blue colour which its oxide communicates to vitrifications, and on its uſes as a fixed colouring principle in the arts.

A new experimental reſearch, undertaken in the laboratory of the School of Mines, upon the ores of cobalt, and on its purification, and terminated ſince the impreſſion of the article of my work relative to that metal, permits me to add ſeveral facts in the place which could not poſſibly form a part of that article.

The beſt method of obtaining cobalt pure from its ores conſiſts in the following proceſſes: 1ſt, in calcining them for a long time, adding every quarter of an hour ſome powder of charcoal, or oil, to favour the evaporation of the arſenic; 2d, in diſſolving them in nitric acid, evaporating to dryneſs, and re-diſſolving them in water; 3d, in precipitating by pure potaſh, and

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cauſing the depoſition to boil with a ley of the ſame alkali; 4th, in waſhing the depoſition well, diſſolving it in acetous acid, and evaporating it ſeveral times to dryneſs; 5th, in rediſſolving it in water, precipitating it by ammonia, filtering and taking up the depoſition by the ſame volatile alkali; 6th, laſtly, in evaporating this ammoniacal ſolution to dryneſs, and ſlightly calcining it to ſeparate all the ammonia. A reddiſh brown oxide is thus obtained, which, fuſed by the heat of a forge with a mixture of black flux, of borax, and a little oil, reduced into a paſte, affords cobalt very pure, and in which no re-agent can ſhow any veſtige of iron.

Cobalt thus purified has a ſlightly-red colour; it is ſometimes lamellated, frequently granulated, and ſometimes fibrous; its ſpecific gravity = 7.700. It is attracted by the magnet, though it does not preſent any perceptible indication of iron. Its fuſibility approaches that of crude iron. It does not oxide in the air; at a high temperature, it burns with a red flame, and leaves a black oxide. This oxide gives a very intenſe blue colour to fifty parts of glaſs. All the ſalts of cobalt are precipitated of a roſe colour by the alkalis, an exceſs of which gives a blue colour to the depoſition. Ammonia, in diſſolving the oxide of cobalt, aſſumes the red colour of wine. Cobalt precipitates copper and nickel from their ſolution in the metallic ſtate.

Nickel, the ſubject of the ninth article, like cobalt is treated at conſiderable length, after the experiments to which Bergmann ſubmitted it in 1775. Very little has been added ſince that excellent work. I have omitted none of the peculiar properties which have been acknowledged to belong to nickel. They prove that, notwithſtanding the opinion of many mineralogiſts who conſider it as a ſimple mixture, this metal is very diſtinct and well characterized as a particular ſubſtance. The ſame reſult has alſo been obtained by the laſt reſearches made in the laboratory of the School of Mines, ſince the impreſſion of the preſent article. Theſe new experiments have diſcovered or confirmed the following truths.

Kupfernickel is a compound of arſenic and of nickel. Iron, cobalt, and copper are only accidentally preſent. The ſmall quantity of ſulphur which it contains is united with iron in the ſtate of pyrites. The green effloreſcence of this ore is the arſeniate of nickel.

To extract the metal, it is roaſted with the addition of charcoal. The roaſted ore is then diſſolved in nitric acid; if it contains copper, this is precipitated by iron; the ſolution is then evaporated to dryneſs, diſſolved in water, and precipitated by pure potaſh, which is made to boil on the depoſition; the precipitate is filtered and well waſhed; then re-diſſolved in acetous acid; evaporated to dryneſs by a mild heat;

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the acetite is again diſſolved; precipitated by ammonia in exceſs, which diſſolves the oxides of nickel and of cobalt; the ſolution is evaporated which depoſits the oxide of cobalt in red powder; the liquor, containing only nickel, becomes blue; it was before purple by the preſence of cobalt. By evaporating it to dryneſs, an oxide of nickel of the green colour of the leek is obtained, which gives to borax the red colour of the hyacinth without any mixture of blue. A paſte is made with oil and this oxide, to which two or three parts of black flux is added; this is placed in a crucible, covered with borax and marine ſalt; it is heated in a good forge-fire during an hour and a half: the nickel is obtained free from cobalt and iron.

The metal thus prepared is nearly as white as ſilver, and leaves on the touchſtone a trace ſimilar to that of that metal; its ſpecific gravity is 9,000. Its denſity reſembles that of ſoft iron, though it may eaſily be cut with a knife. It may be flattened under the hammer, it is laminated without heat more eaſily than iron; it cannot be annealed without burning and breaking it; it becomes covered during annealing with a greeniſh yellow powder; if too ſtrongly heated by annealing, its grain is of a purple violet. It is ſtrongly attracted by the magnet, and capable of receiving magnetiſm like iron. A needle of this metal, touched by the ordinary proceſſes, aſſumes the north and ſouth direction, when ſuſpended by a thread of ſilk. It has been propoſed on this account to be uſed in ſea compaſſes.

Iron, zinc, tin, manganeſe, and cobalt itſelf, precipitate nickel from its ſolutions in the metallic ſtate. The alkalis ſeparate a greeniſh oxide; the gall nut precipitates it of a greeniſh white; the pruſſiates, of a greeniſh grey, and the hydro-ſulphurets of a deep black.

Manganeſe, the ſubject of the tenth article, is too important, principally ſince the ingenious application of the diſcoveries of Scheele concerning that metal to the pneumatic doctrine, for me to fail in giving to its hiſtory all the extent which it merits. The reader will ſee in this article, which is one of the longeſt of thoſe conſecrated to the brittle and ſimply oxidable metals, beſides ſeveral facts of my own, concerning the oxidability of this metal, that its combuſtibility among metals equals that of phoſphorus among non-metallic combuſtibles, that the reduction of its oxides, its different degrees of oxidation, how much the actual ſtate of ſcience in France, and the order which have followed in conſequence of this advanced ſtate, throw light on the ſum and arrangement of the properties of this body, which was almoſt entirely unknown twenty-five years ago, and is become, at preſent, one of the moſt remarkable inſtruments of the chemiſt, and one of the moſt important re-agents in ſeveral of the arts.

Biſmuth, treated in the eleventh article, and well known for more than a century, becauſe it is long ſince its particular uſes have diſtinguiſhed it from all other metallic ſubſtances, has ſcarcely any thing more in its hiſtory than I have already mentioned in my Elements of Chemiſtry, except the different order in which I have conſidered its properties, the much more extenſive accounts of moſt of them, and particularly the clearneſs which the pneumatic doctrine and the method which it has dictated to me has given to theſe combuſtible bodies.

Antimony, the twelfth article, a metal ſtudied for ſeveral ages, with indefatigable ardour, by the alchemiſts, who have always conſidered it as one of their moſt precious re-agents; by the pharmacologiſts who, in the midſt of their ridiculous pretenſions concerning the medicinal alkaheſts and the panacea, have diſcovered ſeveral very uſeful medicines, muſt be examined with particular care, on account of the numerous combinations to which it gives birth. Accordingly its article is much more extended than thoſe of the other brittle unacidifiable metals; it is in a manner twice as extenſive, becauſe it is required to indicate not only the ſaline compounds formed by the metal, but alſo the compounds of its ſulphuret, much more frequently employed than the metal itſelf in the pharmaceutic and uſual preparations. We were formerly loſt in the labyrinth of incoherent and inexplicable facts, which compoſed its chemical or rather pharmaceutic hiſtory. One of the moſt ſtriking reſults of the great advantages of the pneumatic doctrine, is the illumination of all the phenomena which formerly offered the deepeſt and moſt inexplicable obſcurities; —the explanation and union of all the other facts which, in the ancient chemiſtry, had neither relation among themſelves, nor even any apparent connection: ſuch was the chemical hiſtory of antimony. The ſimplicity and clearneſs of the preſent chemiſtry has permitted me to give to this hiſtory what was wanting to it a few years ago. The recent diſcoveries of Citizen Berthollet concerning hidro-ſulphurets, and of Citizen Thenars, concerning the different ſtates of the oxidation of antimony; diſcoveries of which I have made an almoſt continual uſe in the compoſition of this article, have greatly contributed to give clearneſs and order to all the articles appropriated to the metals in particular.

Tellurium, the thirteenth article, a brittle metal, confounded at firſt with antimony, diſcovered as a particular metal, about two years ago, by M. Klaproth, in certain ores of gold of Tranſylvania, ſo remarkable for its extreme fuſibility, its volatility, which almoſt equals that of mercury, its oxide of a yellow ſtraw colour, very fuſible, very cryſtallizable, very reducible, very ſoluble in the alkalis, deſtined to occupy the middle place in chemical arrangement between antimony and mercury, has been deſcribed only after the experiments of the chemiſt of Berlin, becauſe none but him has yet been occupied on this new metal, of which the ores are very ſcarce. They have not yet been found except in Tranſylvania.

Mercury, the ſubject of the fourteenth article, is of ſuch importance in all its properties; the numerous diſcoveries which relate to it are combined ſo directly with all the truths of chemiſtry, as well as with the greater part of human knowledge, that I have thought it neceſſary to give all the ſcope to its hiſtory, of which it is ſuſceptible. By including in a certain degree in the aggregate of its properties, all the facts calculated to exhibit the foundations of the moſt important theories of the ſcience, I have preſented it as one of the bodies poſſeſſing the greateſt influence on the progreſs of chemiſtry, and natural philoſophy in general, and I have, for that reaſon, been led into very great details concerning this metal. Hence its article is one of the longeſt of thoſe which relate to metallic ſubſtances.

I have ſhown, in the firſt under-title, A, how much chemiſts have been employed upon it in all times, and to how many diſcoveries it has given birth.

I explain, in the ſecond, B, all its phyſical properties, its brilliant luſtre, its diviſibility into globules, its dry fluidity, its condenſability, its ſolidification by cold, its congelation and cryſtallization effected by different cooling proceſſes ſince 1759 to our time; its ſlight ductility in the ſolid ſtate, its dilatability by caloric, its vaporoſity and volatility, its property of conducting electricity and caloric, its luminous and electric quality, its odour and its taſte. I have been careful to aſcend to the ſource of each of the diſcoveries which concern its properties.

The third under-title, C, relates to the different ſtates of mercury in the interior of the globe. I have reduced them to four; namely, native mercury, amalgamated mercury, red ſulphurated oxide of mercury, and the muriate of mercury. I have indicated the varieties of each of theſe ſtates, the only ones which nature preſents of this metal.

In the fourth under-title, D, I have compriſed the docimaſy and the metallurgy of mercury. The firſt preſents the principal aſſays in the dry and the humid ways, which it has been uſual to make, to diſcover its ores, as well as thoſe which have been employed to eſtimate its purity; the ſecond contains an outline of the proceſſes which have been practiſed in different countries to extract the mercury from minerals which contain it.

In the fifth, E, I conſider the oxidability of mercury by the air; I there trace the courſe which chemiſts have followed to obtain it, from the time when they have thought it impoſſible, to that in which they diſcovered how it takes place. I deſcribe the different degrees of that combuſtibility which have been ſo long unknown, and I inſiſt on the firſt black oxidation, as well as the different ſtates of the red oxide, and its reduction which announces the varied attraction of the different portions of oxigen which are united with it.

The ſixth under-title, F, explains the combinations of which this metal is ſuſceptible with combuſtible bodies, particularly thoſe with phoſphorus, ſulphur, and ſome metals which form the moſt numerous and the moſt varied of its compounds: all their properties are explained with much more detail, and carried much farther than it has been uſual to do in all the books of chemiſtry.

The ſeventh under-title, G, which relates to the action of mercury on water and on the oxides, is much ſhorter, becauſe this action is little, or at leaſt very weak; it is one of the metals which acts leaſt powerfully on theſe bodies.

This is not the caſe with the acids, treated with mercury in the under-title, H. This is one of the moſt extenſive, and abounds with the greateſt number of new facts. All the acids, but principally the ſulphuric, the nitric and the muriatic, exerciſe an action on mercury, or an attraction on its oxides, which produce a great number of important phenomena and remarkable combinations. Modern diſcoveries have greatly extended, and given preciſion to our knowledge of theſe combinations. Much information will be found concerning the ſulphates, the nitrates, and the muriates of mercury, hitherto ſo little known, together with conſiderations very different from what have been offered till the preſent time concerning theſe ſalts. The labours of Scheele, of Bergmann, of Lavoiſier, of Citizen Berthollet, and myſelf, on the greater part of theſe combinations, have afforded me an abundant harveſt of new facts and of happy explanations, which juſtify me in announcing this part of the hiſtory of mercury as the moſt profound, as well as much more advanced, than any thing that has yet been preſented on the ſame ſubject. I may affirm as much of the ſulphite, of the phoſphate, of the chromate of that metal, of which, indeed, the greater number of works, either have not yet mentioned, or have at moſt only indicated the exiſtence. Of the different parts or ſub-diviſions which compoſe the treatiſe on mercury, this is the moſt detailed, the moſt complete and the moſt elaborate.

There are comparatively but few details in the following under-title, I, becauſe the ſalifiable baſes and the ſalts, which are there conſidered, have very little effect on mercury, and are but very ſlightly affected by it. But I have carefully deſcribed the effect which the oxide of that metal receives on the part of the alkalis, and particularly ammonia, and the ſlow action which mercury exerciſes on the muriates, eſpecially that of ammonia.

The laſt under-title, K, where mention is made of its uſes, contains ſome new reſults concerning its medical action and its cauſe.

I have given this extended notice reſpecting mercury, in order that the reader and ſtudent may form a proper eſtimate of the courſe I have followed, and the care I have taken in the expoſition of the moſt important metals.

Zinc, which follows in the fifteenth article, is placed there in the order which I have adopted, becauſe it approximates to the metals properly ſo called, principally to tin, which immediately follows it, and with which chemiſts have long obſerved ſtrong analogies. Several new facts will be found in its hiſtory concerning its influence in galvaniſm, concerning its ores, its aſſays, its alloys, its combinations with hidrogen, with phoſphorus and the acids.

Tin is treated in the ſixteenth article with a degree of accuracy which does not yield to that of the other articles, either in the expoſition of its phyſical properties, of its ores, of its aſſays, or in that of its combination with phoſphorus, ſulphur and the other metals, particularly its combinations with the acids. The diſcoveries of Citizens Adet, Guyton and Pelletier, on the nitrate and the muriates of this metal, have furniſhed me with details which have not yet been compriſed in the treatiſes of chemiſtry.

Lead, included in the ſeventeenth article, is ſtill one of the metals which have required to be treated moſt at large, becauſe its numerous properties and multiplied combinations are very well known. The pneumatic doctrine has greatly contributed to render its hiſtory eaſy, methodical and complete. Every department, the diſpoſition and the knowledge of its numerous ores, their aſſay by the dry and humid ways, their metallurgical treatment, the oxidation of this metal by air, its union with phoſphorus, ſulphur, the metals, its alteration and ſolution in the acids, its action principally in the ſtate of oxide on the alkalis and the ſalts, receive at preſent the greateſt light and clearneſs from the principles of the French doctrine. The recent diſcoveries concerning its laſt oxidation of a brown colour, obſerved by Scheele, and ſince ſo well developed by M. Prouſt and Citizen Vauquelin, concerning many of its combinations with the acids, concerning ſome of its ores, concerning the effect which the oxides have on ſome of the muriates, have been of great advantage to me in ſtating the new facts relative to that metal.

How amply might I enlarge upon the eighteenth article, devoted to iron, if I were fully to explain what conſtitutes the hiſtory of each of the metallic ſubſtances particularly treated in this ſection! This metal, ſo different from the others in its characters, its magnetiſm, its preſence in organized bodies, its abundance even at the ſurface of the globe, which it ſeems to preſent to man as one of his firſt and moſt important materials of art. This body, ſo varied in its forms, ſo multiplied in its uſes, which add a power and a new force to the human mind, from the art of moving the heavieſt maſſes, to that of tracing on the pathleſs ocean the courſe which the navigator purſues; from the uſe of the ſimpleſt and rougheſt lever, to that of the delicate ſpring which enables the time-piece to move, and the delicate graver to tranſmit to future ages the images of our heroes and their glorious achievements;—this being which meaſures, in a certain reſpect, the comparative intelligence and perfection of nations, by the number of the ſervices which they know how to obtain from it, and the different ſtates which they have given to it, preſents to the philoſopher, the geometer, the navigator, the aſtronomer, the phyſician, and the mechanic, ſources ſo multiplied, inſtruments ſo precious, advantages ſo great, that the chemiſt, whoſe labours muſt precede and direct the different applications of this metal, cannot develop its properties with too much care. Theſe are the motives why I have given ſuch extenſive details reſpecting iron. Its hiſtory, exceeding in length even that of mercury, and divided into ten under-titles, like that of all the other metals, contains, in each of theſe diviſions, all the facts relating to it, all the diſcoveries ancient and modern, and all the uſeful conſiderations afforded by their reſults. An account of the labours to which it has been ſucceſſively admitted; an accurate diſplay of its phyſical properties ſo ſingular and ſo diſtinctive;

tive; a methodical claſſification and deſcription of its ores, after the late remarks of Citizen Haüy; accurate generalities concerning its docimaſy and metallurgy; phenomena and reſults of its different degrees of oxidability by the air; its combinations with hidrogen, carbon, phoſphorus, ſulphur and the metals; compariſon of crude iron, bar iron, and of ſteel; extenſive details reſpecting its alloys; the action which it exerciſes ſo ſtrongly on water and the oxides, which it decompoſes, almoſt all with equal facility; the multiplied effects which it experiences on the part of the acids, and which it cauſes them to undergo; the very detailed expoſition of its different ſaline combinations; the two ſtates of its ſulphate, thoſe of its different precipitates; the adherences which it contracts, the compounds which it forms, the colours which it aſſumes and which it communicates to the earths, the alkalis and the ſalts: this is the ſeries of objects methodically preſented in this article. However long it may appear, it is far from exhibiting the immenſe profuſion of details contained in ſome ancient and modern works concerning iron; but it nevertheleſs contains a much more extenſive ſeries of facts, and particularly a connection, and unity of theſe facts, much more valuable than any of the treatiſes publiſhed on this important ſubject. This article may be conſidered as a monographic hiſtory of this metal, drawn up with all the preciſion and method of which I was capable,

ble, forming, by the aſſiſtance of the pneumatic doctrine which enlightens all its parts, the moſt complete ſyſtem of the knowledge we at preſent poſſeſs reſpecting iron.

The article of copper (the nineteenth), though much more conciſely treated than iron, contains nevertheleſs a great number of facts concerning its properties. I have had leſs to ſay concerning the hiſtory of its diſcoveries, and its phyſical properties. Its different ſtates in nature, its ores, which conſtitute ſeries very numerous, and much varied in their form and their colour in collections, have engaged me more particularly to reduce them to ſpecies really different. The under-title, D, concerning its aſſays and its metallurgy, has notwithſtanding required ſome extent on account of the importance and the number of its operations, though I have been deſirous only of ſummaries; but the diviſions relative to its properties truly chemical, to the actions of the air, of water and of the oxides, the acids, the baſes, and the ſalts upon copper, are the moſt elaborate and the moſt detailed parts. Among all the facts anciently known concerning its properties, we may ſelect in a certain manner, as the neweſt and the moſt ſtriking, the different ſtates of the oxides of copper, their differences, their reſpective tranſitions, the combinations of this metal with phoſphorus and ſulphur, the beautiful phoſphoreſcence of the ſulphuret of copper, ſeveral of its alloys relative principally to the art of analyſis, ſuch as braſs and bell-metal, the ſulphite of copper, unknown before the reſearches which were common to me and Citizen Vauquelin; the nitrate of copper and its precipitate by ſlaked lime, which forms verditer, the differences of the arſeniate and of the arſenite of copper, the firſt bluiſh, the ſecond forming the green pigment of Scheele; laſtly, the action of ammonia on its oxides. It will conſtantly be ſeen that the pneumatic doctrine imparts to the whole of the hiſtory of this metal a clearneſs and preciſion which did not exiſt in it before the admiſſion and the conſolidation of that beautiful theory.

Silver, gold and platina, articles XX, XXI, and XXII, forming together the laſt genus of metals, becauſe they reſemble each other in their great ductility and their difficult oxidability, conſtantly united on account of their relations under the ancient name of *perfect metals*, the objects of the long and patient reſearches of the alchemiſts, who, without finding the tranſmutations they ſought, have at leaſt found a number of combinations which they did not ſeek for, are treated with the care and details ſuited to their importance. Their chemical hiſtory has gained no leſs by the certainty and the ſimplicity of the reſults of the pneumatic doctrine, than that of all the preceding metals. Moſt of the phenomena which relate to them and the particular facts they preſent, depend on the little attraction which exiſts between them and oxigen, on the difficulty with which they are united, and on the facility with which that principle is ſeparated from them. It is by theſe means that they poſſeſs their unchangeableneſs in the air, the neceſſity of violent means, ſuch as deflagration to burn them, the ready reduction of their oxides, the ſlight action of moſt of the acids on theſe metals, the power which the oxigenated muriatic acid exerciſes on them, the very remarkable alteration which their oxides undergo by ammonia and the fulminations of which their combinations with that alkali are ſuſceptible. The art of purifying theſe metals, of extracting them from their alloys, of obtaining them without loſs or with little loſs, and of aſſaying them, or of diſcovering their fineneſs, depend on the firſt mentioned chemical characters. We muſt ſee, in a word, that this ſlight adherence of the three laſt metals for oxigen muſt be conſidered as the point upon which all the properties which characterize them turn; as we have ſeen that the more or leſs ſtrong attraction of all the others for that principle, is the only centre of the varied phenomena which they preſent to us. The great ſimplicity which this obſervation imparts to their hiſtory, muſt render it ſhorter and more eaſy to be underſtood than that of ſeveral of the other metals. Thus, though I have omitted nothing to render that hiſtory complete, the three laſt articles are much leſs extenſive and ample than moſt of the preceding.

I have nevertheleſs given ſufficient development to the hiſtory of the ores of ſilver, of its alloys neglected in the elements which we poſſeſs, of its ſaline combinations, particularly of its nitrate and muriate, of their decompoſitions by the other metals, of fulminating ſilver, a ſpecies of ammoniacal argentite, of the non-decompoſition of its muriate by the fixed alkalis, of the contrary decompoſition of the muriate of ſoda by the oxide of this metal, and laſtly, of the uſes of ſilver.

I have been careful, in the hiſtory of gold, to inſiſt on its excellent phyſical properties, on the aſſays and the treatment of the auriferous minerals, on its oxidation by the air, on certain of its alloys not ſufficiently deſcribed or diſtinguiſhed in the greater number of chemical works, on its purification, its refining, and the important art of aſcertaining its fineneſs; on the muriate of gold, on the relations of the muriatic ſolution of gold with that of tin, on the purple powder of Caſſius; and laſtly, on the uſes of that precious metal. All this article, formerly obſcure, and filled with incoherent facts, has acquired, by means of the pneumatic doctrine, a degree of preciſion and clearneſs which were ſought in vain in the ancient doctrines of chemiſtry. The phenomena of its different precipitates, and alſo of the greater number of its combinations, which were formerly inexplicable, have acquired a perſpicuity which, by rendering them eaſy to be underſtood, has neceſſarily added to the force of the theory to which it is due.

Platina, though ſubmitted to a great number of ſucceſſive reſearches during more than forty years, is ſtill much leſs known than ſilver and gold. Hence certainly ariſes the extreme difficulty of obtaining it pure, and of examining it alone and without alloy. There is room to hope that the preſent means of chemiſtry and the great occaſion for working this refractory and almoſt infuſible metal, in the fabrication of ſtandards for the republican weights and meaſures, will open to the chemiſts of the Inſtitute of France a new courſe. Their firſt eſſays already promiſe us more exact information concerning the properties of this fine metal. But this new work has ſcarcely commenced. It was impoſſible for me to inſert the firſt reſults which have been preſented to us in my article of platina, becauſe they are not yet ſufficiently confirmed. I have therefore been forced to recur to the known ſources, and to leave either obſcurities or great defects in this article. But I have taken care to preſent the facts moſt recently diſcovered concerning platina, ſuch as the proceſs of working it which Citizen Jeannety has uſed at Paris; its fuſion by oxigen gas, deſcribed by Lavoiſier; the principal alloys which it forms, and which are all more or leſs important to be known; its ſingular combination with phoſphorus, of which Pelletier has ſought to avail himſelf to purify the metal, the triple ſalts ſo numerous and ſo frequent to which it gives birth, and which all, when ſtrongly heated, conduct to its reduction and purification; its remarkable oxidation and apparent deſtruction by nitre, ſo well obſerved by Margraaf, Lewis, and afterwards ſo much better determined by Citizen Guyton; the aſſays already attempted on its ſeparation from the other metals by different precipitants from its ſolutions, &c.

Thus the ſection of metallic matters, treated with all the neceſſary details in each of its articles, does not yield, by the developments which conſtitute them, to any of thoſe which precede it: theſe bodies, ſo important in ſociety, are ſtudied in all their properties, in ſuch a manner that no work preſents ſo extended and ſo complete an account of them.

NOTICE OF THE SEVENTH SECTION.

VEGETABLE matters, of which the hiſtory belongs to the ſeventh ſection of the ſyſtem, being compounds very different from thoſe which exiſt among the foſſils, and the problems which chemiſtry propoſes to ſolve concerning the nature of theſe matters being of an order more elevated than thoſe which mineral compounds preſent, the courſe of the ſcience could not be the ſame in this ſection as that which directed me in the preceding ſections. The ſimple diviſion into articles are not here ſufficient. The chemical phenomena which characterize vegetable compounds are too complicated and too numerous, not to demand a preliminary diſtinction in their comparative differences. It is neceſſary beſides, in order to underſtand them well, to know in what the organic ſtructure of plants differs from the lamellated, fibrous or granulated, but always ſimple texture of foſſil matters. In this examination, it is no leſs neceſſary to know the chemical nature of vegetable matters in general, than that of the immediate materials of plants in particular; to determine how the chemical proceſſes of nature differ from the proceſſes of art with reſpect to them, as well as the relations which may be eſtabliſhed between their chemical properties and the phenomena of vegetation. Theſe conſiderations reſpecting vegetable chemiſtry, ſuch as it is when treated according to the modern diſcoveries, have led me in the firſt place to divide the ſeventh ſection into ſix orders of facts.

In the firſt, I examine the ſtructure of vegetables and the differences which they preſent when compared with unorganized bodies.

In the ſecond, I treat of the nature or the chemical compoſition of plants in general.

The third order of facts is conſecrated to the examination of the chemical properties of vegetable ſubſtances in general.

The fourth order of facts is deſtined to explain the different materials of plants in particular.

To the fifth order of facts belong the ſpontaneous alterations of which vegetable matters are ſuſceptible.

Laſtly, I rank in the ſixth and laſt order of facts relative to vegetable chemiſtry, the chemical phenomena which the life of plants preſents, or the chemical explanation of the functions exerciſed by living vegetables.

I ſhall recapitulate each of theſe ſix orders for the purpoſe of rapidly explaining what conſtitutes them.

The firſt, treating of the ſtructure of vegetables, is divided into four articles, and comprehends, ſucceſſively, 1ſt. the exterior ſtructure of plants, or the enumeration of their external parts, according to the method and nomenclature of the botaniſts; 2d. their anatomy, or the ſtructure of their interior organs; 3d. an expoſition of the apparent phenomena of their life; 4th, that of the general uſes of vegetables in the economy of nature. This is a ſlight ſketch of philoſophical botany, intended to ſerve as an introduction to vegetable chemiſtry.

The ſecond order of facts, having for its object the general chemical compoſition of vegetables, is alſo divided into four articles. In the firſt, I ſhow the ſeries of diſcoveries which have been made in vegetable chemiſtry, from the firſt chemico-pharmaceutic recipes of the Arabians, to the ſublime reſearches of Lavoiſier and of the moderns; in the ſecond, I indicate the different methods of analyſing vegetables, and I reckon eight ſpecies; in the third, I announce the general reſults of all theſe analyſes with regard to vegetable compoſition; and, in the fourth, I ſhow the moſt general applications of the facts diſcovered by analyſes, to the phenomena of vegetable life, and to thoſe of the alterations which plants undergo after death.

A greater number of articles has been required to include in the third order of facts every thing that relates to the chemical properties of vegetable compounds collectively conſidered. This order is divided into eight articles. The firſt treats of what I underſtand by theſe general properties; I there ſhow that it is eſſential to examine how the vegetable compound differs from the mineral in the mode of the alterations which it is capable of undergoing by re-agents; in the ſecond article, I deſcribe the effects of caloric in different proportions on the vegetable ſubſtance, from its ſimply withering, to its complete decompoſition; in the third, I explain the effects of the air; in the fourth, thoſe of water; in the fifth, thoſe of the acids. This laſt article, though only preſenting a generality, contains facts which have not been before announced, and a much more exact and extended theory than has hitherto been preſented. The ſame is the caſe with the ſixth article, where I examine the action of the earths and of the alkalis on the vegetable compound; and, of the ſeventh, where I treat of the action of the ſalts on that compound; they offer ſeveral reſults of my own, both in the experiments and in the doctrine. The eighth article, the laſt of the third order, which has for its object the action of the metals, of their oxides, and of their ſalts on vegetable ſubſtances, always conſidered in this place as a ſingle compound, alſo preſents original notions concerning the manner of the action of theſe bodies; I there ſhow how they are uſed in the analyſis of vegetable ſubſtances, and the determination of their conſtituent principles.

The fourth order of facts includes the vegetable analyſis properly ſo called, or the examination of all the vegetable matters in particular, that is to ſay of what have been named *the immediate materials of plants*, becauſe they ſerve directly to conſtitute them. It is divided into twenty-four articles, and it comprehends all the details neceſſary to the accurate knowledge of each of theſe materials.

The three firſt articles of that order explain, 1ſt, what is to be underſtood by the immediate materials of plants and the different places they occupy according to their different nature; 2d, the means of extracting them unchanged, in order to acquire a knowlege of them, ſuch as they exiſt in the vegetable texture; 3d, the enumeration and claſſification of theſe materials.

Theſe three articles have been hitherto wanting in all the known works; they are, nevertheleſs, indiſpenſable to guide the progreſs of chemiſts and to render it methodical; they ſerve more particularly to throw a light upon the reſults of vegetable analyſes, hitherto ſought in vain, and to diſtinguiſh this part of the ſcience from the chemical arts, and more eſpecially from pharmacy, with which that kind of analyſis has too long been confounded.

The twenty articles which follow the three firſt, from the fourth article to the twenty-third incluſively, contain the hiſtory of the twenty immediate materials of vegetables, differing from each other, which I conſider in their totality, as conſtituting all the products of the primitive or immediate analyſis of plants. In order the better to deſcribe the characters of theſe materials, I treat each of them preciſely in the ſame manner, ſtrictly following to the ſame order in their examination. Each article is conſtantly divided into ſix titles, preceded by the ſix firſt letters of the alphabet; namely,

A. The ſeat or the place of the plant which contains the ſubſtance is treated of;

B. Its extraction or the proceſſes to obtain it inſulated;

C. Its phyſical properties, form, conſiſtence, taſte, odour, colour, weight, &c.

D. Its chemical properties, or the manner in which it is altered, modified, changed, and decompoſed

compoſed by the different bodies which are made to react on it;

E. Its ſpecies, or rather the different varieties under which that matter preſents itſelf;

F. Laſtly, the uſes to which it is applied.

Thus it is that I examine ſucceſſively the twenty following materials:

1ſt. The ſap analyſed only by the modern chemiſts, containing ſeveral different matters, quickly and eaſily becoming ſour.

2d. The mucus, inſipid, viſcous, and adheſive under the form of mucilage, dry, brittle, and tranſparent under that of gum, affording by heat, water, and acetous acid, altered by a burned oil, which has been taken for a peculiar acid, named pyromucous; affording by the nitric acid a pulverulent and inſoluble acid, reſembling the ſugar of milk, &c. exhibiting itſelf in the laſt analyſis as an hidrogenated oxide of carbon.

3d. Sugar, well characterized and diſtinguiſhed from the mucus by its taſte, its cryſtalline form, the great quantity of water and of acetous acid which it affords by diſtillation, its ſyrupy ſolution in water, and its different degrees of denſity, the abſence of the pulverulent acid inſoluble by the nitric acid, and the excluſive property of forming an alkoholic liquor by fermentation.

4th. The vegetable acids, or rather the vegetable acid in general. This article is treated in a manner ſufficiently new and conſiderably different from what ever has hitherto been ſaid on that ſubject, to require certain details. It is a complete though conciſe hiſtory, of vegetable acidification; I conſider that phenomenon in its greateſt extent, I firſt explain how generally it exiſts in the materials of plants, how theſe materials are acted upon by it; I ſhow the analogy which exiſts between the different vegetable acids, the ſucceſſive converſions or tranſitions they undergo; I divide the different forms of the acid or the modifications of which vegetable acidification is ſuſceptible, into ſix genera: this is the ſubject of the firſt paragraph of the ſeventh article. The ſix following paragraphs comprehend the ſix diſtinct genera of vegetable acids; namely,

The firſt genus or the native and pure acids, to the number of five ſpecies, the gallic, the benzoic, the ſuccinic, the malic, and the citric.

The ſecond genus, or the acidules formed from acids partly ſaturated by potaſh, the oxalic acidule or the ſalt of ſorrel, the tartareous acidule or tartar: the oxalic and tartareous acids are examined in their pure ſtate after each of their acidules.

The third genus, or the empyreumatic acids, produced by the action of fire on vegetable matters; the pyromucous, the pyroligneous, and the pyrotartareous. Since the impreſſion of this article, this genus of acids has been deſtroyed by the new reſearches in which Citizen Vauquelin and myſelf have been engaged. From theſe it reſults that the three diſtilled acids which compoſe it, and which are the products of mucilage, wood, and tartar by diſtillation are merely acetous acid holding in ſolution an empyreumatic oil, ariſing from the action of heat on each of theſe ſubſtances. In effect, when combined with the earths and the alkalis, they afford acetites, entirely ſimilar to each other; no difference is found in this reſpect between the pyromucites, the pyrolignites, and the pyrotartrites; they all afford the identical acetous acid when diſtilled with ſulphuric acid. On the other hand, ſome pure acetous acid diſtilled with the ſpecies of empyreumatic oil obtained from mucilages, from wood or from the tartrites, or even agitated for a time with theſe oils, acquires the ſmell, the brown colour, and all the ſenſible properties which characterize the acids produced by heat; this diſcovery, by multiplying the ſources of acetification, diminiſhes the number of the vegetable acids by three ſpecies.

The fourth genus of vegetable acids, treated of in the 5th paragraph of the ſeventh article, comprehends the new factitious acids different from thoſe which are found in nature, products originating in the action of the nitric acid on vegetable matters. There are three ſpecies in this genus; namely, 1ſt. mucous acid: I give this name to what has been called, in the methodical nomenclature *ſacchlactic*, becauſe it is principally formed with the ſugar of milk; the new name which I have given to it is more general,

neral, and derived from its formation by gummy and mucilaginous bodies, as well as by the ſugar of milk; 2d. camphoric acid; 3d. ſuberic acid. Theſe two laſt, formed by the action of the nitric acid on camphor and on cork, are merely indicated in this article; I treat them with more detail in the particular hiſtory of theſe two matters.

The VIth paragraph, including the fifth genus of vegetable acids, belongs to the artificial acids formed by the action of the nitric acid and imitating thoſe of nature, includes three ſpecies; namely, the factitious malic, tartareous, and oxalic acids. I have here only explained the means by which they are obtained, becauſe theſe acids have already been examined in the IId and IIId paragraphs. I might alſo add here the acetous acid, one of thoſe moſt frequently produced by the nitric acid, if I had not conſidered it in the VIIth and laſt paragraph, where I treat of thoſe formed by the effect of fermentation.

I have, however, referred, according to the order I have adopted, the hiſtory of the acetous and acetic acids to the fifth order of facts, where I have treated of the ſpontaneous alterations of which vegetables are ſuſceptible, and the products of theſe alterations.

5th. The fecula, treated in the eighth article of the fourth order of facts, preſents in the method I have conſtantly followed with regard to all the immediate materials of plants, an intereſt ſo much the greater with regard to the explanation of its ſituation, its extraction, its phyſical and chemical properties, and its ſpecies or different modifications, becauſe its uſes ſhow it to be one of the moſt important ſubſtances for the ſupport of life, as it forms one of the principal articles of food of man and of animals.

6th. The gluten, the ſubject of the ninth article, is treated with great care, becauſe in its combination with fecula in that moſt excellent food, the farina of wheat, it gives it part of the properties which are peculiar to that farina, and, on the other hand, it approaches to animal matters by its chemical characters, owing to the preſence of azote fixed among its principles.

7th. The extract, compriſed in the tenth article as the ſeventh of the immediate materials of plants, has nothing ſimilar to what were formerly named extracts. After having made it, during twelve years, one of the ſubjects of my deepeſt ſtudies, relative to the analyſis of quinquina, I muſt explain its properties in ſuch a manner as to give to it a very different aſpect from what it has hitherto ſhown. It is no longer a pharmaceutic preparation, but a particular body, coloured, ſapid, ſoluble, abſorbing oxigen which renders it inſoluble in water, containing almoſt always the acetites, and which may be as properly reckoned in the liſt of colouring and dyeing matters as of medical matters; it is a more complicated ſubſtance than all the preceding.

8th. The fixed oil, the eighth of the vegetable materials, treated of in the eleventh article, is conſidered under ſeveral new relations, relative to its nature, and its ſituation, its varieties, and its numerous uſes.

9th. The wax and fat of vegetables, the ninth of their materials, not having been before compriſed in this claſs, deſerve to be carefully diſtinguiſhed, as to their nature, their frequency, and their uſes. I ſhow that they are formed from fixed oils, thickened by the abſorption of oxigen, moſt frequently expoſed to the air in ſmall drops or in very ſlender coverings on the ſurface of the grains which contain them.

10th. Volatile oil, the tenth of the immediate materials of plants, is treated of in the thirteenth article, and conſidered chiefly by compariſon with fixed oil. I deſcribe it as a compound in which the predomination of hidrogen forms the principal character.

11th. Camphor, the ſubject of the fourteenth article, is preſented as conſtantly accompanying the volatile oil which it reſembles, but from which however it differs in ſome peculiar characters, particularly by its concrete and cryſtalline ſtate, its ſolubility in the acids, and its converſion into a peculiar acid by the action of nitric acid.

12th. Reſin, the twelfth of the immediate materials of vegetables, the ſubject of the fifteenth article, ſeems to have the ſame relation to volatile oil as wax has to fixed oil. After having preſented their generic characters, after having treated of reſinification in general, I indicate, as I have done with regard to all the preceding materials, the principal ſpecies of reſins employed in medicine, and in the arts.

13th. The gum reſins, the thirteenth ſpecies of the materials of plants, are treated like the reſins. In the ſixteenth article, I give their generic characters, particularly thoſe which tend to diſtinguiſh them from the reſins, and I then indicate the moſt valuable of the ſpecies in common uſe.

14th. Caoutchouc, the fourteenth genus among the materials of vegetables, is particularly conſidered in the ſeventeenth article as a ſubſtance very different from the gums and the reſins, with which it ſeems to have been long confounded by its denomination. I ſhow that it ought to be conſidered as a ſubſtance *ſui generis,* which has very diſtinct phyſical properties and chemical characters. Several trees furniſh this body already ſo uſeful and which will hereafter become much more ſo, if, as I propoſe, the white juice, from which it is ſeparated, be immediately brought from our colonies, and if a ſimilar matter be ſought in thoſe European vegetables which appear to contain it.

15th. The balſams, the fifteenth of the immediate materials of plants, treated of in the eighteenth article, are deſcribed as natural compounds of reſin and of benzoic acid. This denomination ought no longer to be vague as it formerly was; it is no longer applicable to the liquid ſtate of the reſins or to their aromatic odour only: it deſignates the oily juices capable of affording a concrete volatile acid by heat, by water and principally by alkaline leys, which is afterward precipitated by muriatic acid. I ſhow that the number of the balſams muſt multiply in proportion as reſearches concerning vegetables become more exact, and that in addition to benzoin, the balſams of Tolu, of Peru, ſtorax and liquid amber, which formerly were the only ones known in this genus, it is neceſſary to add thoſe of vanilla and canella, becauſe theſe two matters, which contain a very odorous oily juice, afford alſo the benzoic acid by analyſis.

16th. I reckon colouring matters as the ſixteenth genus of the immediate materials of vegetables: they form the ſubject of the nineteenth article. In treating of the coloration of the parts of plants in general, I ſhow that this object, much leſs known than that part of ſcience which relates to the extraction and to the application of colours for painting and dyeing, is one of the leaſt advanced parts of vegetable chemiſtry. I then paſs to the enumeration, the claſſification and the examination of the colouring matters uſeful in the arts; I attempt to reduce to a ſyſtem the practical facts already known concerning theſe matters, and to divide them into chemical compounds, more or leſs different from thoſe which have been before treated of. The new notions concerning vegetable colours, delivered by Citizen Berthollet, are more particularly turned to advantage in this article.

17th, 18th, 1t9h, and 20th. The four laſt immediate materials of plants, upon which I treat after the ſixteen preceding, have not hitherto been conſidered as ſuch by the chemiſts; I am the firſt who have diſtinguiſhed and compriſed them in the claſs of compounds, forming vegetables. Before the courſe which I have adopted they were either unknown or neglected.

I name the ſeventeenth of theſe materials the *vegetable albumen*, on account of its analogy with white of egg or the animal albuminous matter; like that ſubſtance, this matter, which I have found in the farina of wheat, in the juices of ſeveral plants, is coagulable by heat, the acids and alcohol; it appears to accompany the green fecula of expreſſed juices.

The *ligneous matter*, the eighteenth of the materials of vegetables, is their ſolid part, a ſpecies of vegetable ſkeleton. It has erroneouſly been taken for an earth. Beſides its character of affording a great quantity of charcoal by its decompoſition by heat, of preſerving itſelf for a long time without alteration in dry air, of changing its dimenſions according to the hygrometric ſtate of the atmoſphere, the ligneous matter has alſo for diſtinctive properties that it is inſoluble in cold or hot water, that it becomes charcoal by long contact with that liquid, and is converted into ſeveral factitious acids by the action of nitric acid. It is a compound which differs from all others by the ſuperabundance of carbon and of oxigen.

The *tan*, or tannin, has not been before ranked among the immediate materials of vegetables, and I have placed it as the nineteenth of theſe materials, from the care with which it has been examined by Citizen Séguin, in his excellent work on tanning. A ſtrong and as it were aromatic odour, a ſharp and aſtringent taſte, ſolution in water, precipitation from glue, in an inſoluble and conſervable matter, conſtitute its ſpecific characters. It exiſts in many vegetables, almoſt always with the gallic acid, which is diſtinguiſhed from it by precipitating the ſulphate of iron, but does not precipitate animal ſubſtances. Tannin may very probably be the firſt of febrifuge or antiperiodic medicines.

Laſtly, I place *ſuber* in the twentieth and laſt of the immediate materials of plants, which I treat of in the twenty-third article. I call the matter of cork ſuber. It differs from every other vegetable ſubſtance in its texture, its faint ſmell, its weak aſtringent taſte, the nature of the products which it affords by heat, and the kind of acid which it forms with the nitric acid. I reckon ſuber in the number of the immediate materials of plants, becauſe I have found it in the thick bark of the twiſted elm, and becauſe I believe it to exiſt in the epidermis of all trees.

The twenty-fourth and laſt article of the IVth order of facts comprifed in the chemical hiſtory of vegetables treats of matters analogous to thoſe which are known to be foſſil or mineral, but exiſt in vegetables, and form a part of their materials: theſe are the ſalts or ſome metallic oxides, moſt frequently united with mineral acids.

In the fifth order of facts relative to vegetable compounds, I treat of the ſpontaneous alterations of which they are ſuſceptible.

This order comprehends eight articles.

The firſt explains the nature and general cauſes of theſe ſpontaneous alterations. After having defined them as movements which are ſpontaneouſly excited in vegetable ſubſtances, I ſhow that they are owing to the ternary or quaternary compoſition of theſe ſubſtances, and to the multiplied attractions which exiſt between their principles more numerous than thoſe of minerals, as well as to the weaker adherence of theſe principles.

The ſecond preſents thoſe movements which conſtitute the fermentations divided into ſeveral ſpecies.

The third comprehends the ſaccharine fermentation. I prove that the ſugar is formed by a true fermentation which precedes the vinous fermentation; that it is thus re-produced in the maturation of fruits, and in the germination of grains.

The fourth article is appropriated to the hiſtory of the vinous fermentation and of its product. This hiſtory being one of the moſt important parts of chemiſtry, I divide the article which belongs to it into ſix paragraphs. The firſt, contains the definition and literary hiſtory of the vinous fermentation; the ſecond, explains the conditions which are neceſſary that it ſhould take place; the third, the phenomena with which it is accompanied; the fourth, exhibits the properties of its immediate product or wine; the ſifth, thoſe of its remote product, alcohol; and the ſixth, treats of the cauſes or mechaniſm of that fermentation. This diviſion permits me in very few words to preſent all the uſeful facts which this intereſting ſubject of fermentation and the nature of wine includes, and particularly to reſolve with ſimplicity the problem of the converſion of ſugar into wine, of alcohol into ether, of the great inflammability of theſe two products; problems which were regarded as inſoluble ſome years ago, and ſhow in their actual ſolution the progreſs which modern chemiſtry has made in the knowledge of the phenomena of nature. This article is therefore one of thoſe which contains moſt new facts, and differs moſt eſſentially from what exiſted in the ancient works on chemiſtry.

The fifth article treats of the acetous fermentations according to the ſame method as the preceding. I there explain in ſix ſucceſſive paragraphs, 1ſt, the conditions and the phenomena of that fermentation; 2d, the different proceſſes by which vinegar is obtained; 3d, the properties of that ſour liquid; 4th, thoſe of the acetous acid; 5th, the modification of that acid into acetic acid; 6th, its uſes. This object has aſſumed a much more direct intereſt to chemiſts, ſince I have ſhown, by a work which is common to Citizen Vauquelin and myſelf, that the formation of the acetous acid is one of the moſt common and moſt frequent facts of vegetable chemiſtry; that the action of heat, of ſtrong acids, and of a fermentation different from that of which the wines are ſuſceptible, produce acetous acid, by decompoſing a great number of organized vegetable or animal ſubſtances, and that this acid, formed in many different circumſtances, differs in itſelf, accordingly as it is united, either with an empyreumatic oil or with a portion of alcohol, or with other vegetable acids, or with oily ammonia.

In the ſixth article, I ſpeak of the panary and colouring fermentations. The firſt, takes place in fermented paſte of which bread is made; the ſecond, in the vegetable matters which afford certain red and blue colours. Theſe two movements

ments are ſtill little known; there is reaſon to believe however that the firſt is compoſed of the three fermentations, the vinous, the acid and the putrid, ſince Citizen Vauquelin has diſcovered acetous acid and ammonia completely formed in bread, and that the ſecond is a ſeptic decompoſition, ſince it gives out a fetid odour and much ammonia. Theſe two kinds of fermentation deſerve a ſtill more profound ſtudy, and obſervations more preciſe than thoſe which have hitherto been made on this ſubject.

The ſeventh article is devoted to the vegetable putrid fermentation. I there conſider, in four paragraphs, 1ſt, the ſteeping of hemp, flax, &c,; 2d, rotten wood; 3d, dung; 4th, mould. Theſe are the four circumſtances and the four moſt frequent and moſt remarkable products of the ſeptic decompoſition of vegetables: they have not yet been compriſed till now in the outline of vegetable analyſis; I have thought it neceſſary to apply it to this part of chemiſtry, which is ſtill in its infancy. They preſent facts uſeful, at the ſame time, to the philoſophy of the ſcience, and to the arts which depend more or leſs directly on this ſubject.

The eighth and laſt article of this fifth order of the chemiſtry of plants, has for its object the ſlow decompoſition and the different alterations of which vegetables are ſuſceptible when they are buried in the boſom of the earth. I examine, in four paragraphs, 1ſt, foſſil wood; 2d, peat;

2d, peat; 3d, the bitumens, 4th, petrified wood. The bitumens, a ſpecies of ſubterraneous products from buried wood, have required the moſt extended details in this article. After having explained their general characters, I divide them into four principal ſpecies, which I conſider ſucceſſively; namely, liquid bitumen, pit-coal, jet, and amber.

Since this article of my work was printed, chemiſts have been occupied in the careful examination of a combuſtible foſſil diſcovered ſome years ago in Germany, and which has been named *honigſtein* by Werner, *honey-ſtone* or *mellite* by other naturaliſts. This foſſil, of a yellow colour like ſtraw, but rather deeper, is found in the bituminous woods: it was at firſt compared to amber. Its primitive form, according to Citizen Haüy, is a rectangular octahedron; its cryſtals frequently preſent truncated octahedra, of which the terminal facets are curvilineal: they ſometimes preſent dodecahedrons, approaching to a rhomboid. According to the ſame obſerver, the mellite has a very ſenſible double refraction, while amber has only a ſimple refraction; its inſulated cryſtals eaſily acquire a ſtrong reſinous electricity; but it is ſcarcely ſenſible, when its cryſtals are rubbed without inſulation.

M. Klaproth, in analyſing the mellite, found it to contain alumine and a peculiar vegetable acid.

Citizen Vauquelin has communicated to me an examination which he has lately made of ſome ſmall cryſtals which were ſent to him by M. Abildgaard of Copenhagen, or given by M. Monthey, profeſſor of chemiſtry, in the ſame city.

The mellite is inſipid and inſoluble in water. When heated in a retort, it is decompoſed, and affords a bituminous and empyreumatic water, carbonic acid, and a concrete volatile ſalt; the reſidue is coal. Upon ignited charcoal or in an open crucible, it burns like a vegetable combuſtible: inſtead of leaving charcoal, after its combuſtion, it only preſents a greyiſh white matter, which has all the characters of alumine, mixed with a little lime.

The cauſtic fixed alkalis diſſolve the mellite almoſt totally, and only leave a little undiſſolved lime and charcoal. The alkaline carbonates decompoſe it with efferveſcence; a deep brown reſidue afterwards remains, compoſed of alumine, of a little lime, and of a brown bituminous oil. By burning this laſt reſidue, it becomes white, and affords by the ſulphuric acid ſulphate of lime and ſulphate of alumine, which is changed into alum by the addition of ſulphate of potaſh.

The potaſh with which the mellite was treated is in a ſaline and very ſoluble ſtate. An acid added in exceſs to the concentrated ſolution of that ſalt, ſeparates from it brilliant, acidulous, yellowiſh cryſtals, which greatly reſemble the oxalic acidule, but however differ from it in certain properties. Like the oxalic acidule, it precipitates the aqueous ſolutions of lime, of barytes, of ſtrontian, of muriate of barytes in cryſtals, thoſe of mercury, of lead, and of ſilver in the nitric acid; but while it precipitates, like the firſt, the ſolution of the ſulphate of lime, the acidule of mellite forms tranſparent cryſtals, whereas the oxalic acidule only affords a pulverulent and opaque precipitate. It differs alſo from it, in precipitating the ſolution of the ſulphate of alumine; which the oxalic acidule does not. Laſtly, it is much more inflated on charcoal, and emits much more ſmoke. Theſe two differences appear ſufficient, according to Citizen Vauquelin, to diſtinguiſh the acid of mellite, and to conſider it with M. Klaproth as a peculiar acid.

The mellite, or honigſtein, is then a ſalt with a baſe of alumine and a peculiar vegetable acid, mixed with a little lime and bitumen: it is produced, like amber, from the ſubterraneous decompoſition of trees, and belongs to the ſame claſs of natural products.

After the examination of the bitumens, I ſhow that the petrifaction of wood which has been the ſource of ſo much error in natural hiſtory, is not, as has been thought, a converſion of ligneous fibres into ſtone, but a real depoſition of the earthy ſubject, in a mould left by the vegetable fibres in the boſom of the earth, with which they have been on all parts environed ed and preſſed. And thus by the laſt trace of their exiſtence which vegetable compounds leave, I terminate the outline of the chemical phenomena to which theſe compounds give origin.

The ſixth and laſt order of facts which conſtitutes the whole of vegetable chemiſtry includes the chemical phenomena which living vegetables preſent, or the vegetable phyſiology explained by the chemical powers. This order is, under a certain aſpect, the completion of the whole of vegetable chemiſtry; it comprehends the moſt immediately uſeful reſults and applications which that genus of analyſis preſents to the philoſopher. I endeavour to prove that the philoſophy of vegetables is entirely comprehended in chemical experiments, that chemiſtry alone can reſolve the different problems, and that without it there would be nothing but obſcurity or myſtery in this department of human knowledge.

To prove this aſſertion, I divide this ſixth order into ten articles.

The firſt article exhibits vegetables as ſpecies of inſtruments or chemical apparatus deſtined by nature to unite, in triple compounds at leaſt, the materials which they derive from the different media in which they find their nouriſhment.

In the ſecond article, I conſider the nutrition of vegetables in general as an operation performed by a ſeries of chemical combinations of which the reſult is to form the vegetable compound.

In the III, IV, V, VI, VII, and VIII articles, I conſider the influence which light, air, water, carbonic acid gas, the ſoil and manures exerciſe on vegetation. I ſhow that among theſe matters, ſome are the auxiliaries or the means which favour the development of plants; and that others are the materials more or leſs alimentary in themſelves, or carrying with them, as vehicles, nutritive ſubſtances which undergo either decompoſition or new combinations, frequently both at the ſame time: ſo that the reſults are a formation of compounds more or leſs complicated, which gradually augment the maſs and extent of vegetables, and of which a uſeleſs, ſuperfluous or dangerous portion, flows externally to their ſurface, either in liquids, or in gaſeous fluids.

The ninth article is deſtined to explain thoſe chemical effects which take place in the exerciſe of the vegetable functions. I there ſhow that all theſe functions are the products or the reſults of true chemical operations, of decompoſitions, and recompoſitions ariſing from elective attractions. I ſucceſſively enumerate, as vegetable functions, the motion of the ſap, ſecretion, irritability, nutrition, extravaſation, tranſpiration, direction, ſleep, germination, foliation, flowering, and fructification. I do not content myſelf with ſhowing the chemical phenomena of each of the functions; but I likewiſe prove that they can be nothing elſe than the real effects of attractions which produce the change and the new compoſition of the matters conveyed from without into vegetables.

Laſtly, I preſent, in the tenth and laſt article of this ſixth order of facts, a rapid ſketch of the modifications which art produces in living vegetables, of the alterations which they undergo by a number of external cauſes, or of the diſeaſes which attack them. In a general view of the varieties which culture produces in plants, or ſurrounding cauſes produce in them, foreign to a ſound ſtate, I ſhow that the whole is nevertheleſs ſubmitted, in this kind of conſideration, to the influence of chemical agents and powers.

It muſt follow from all the facts contained in this ſeventh ſection of my work, as I endeavour to prove, that vegetable chemiſtry, far from being limited to the ſtudy and the amelioration of certain arts, as was formerly the caſe, is now elevated to the taſk of explaining and accounting for the greateſt phenomena of nature.

NOTICE OF THE EIGHTH SECTION.

Concerning Animal Compounds.

THE eighth ſection, appropriated to the chemical hiſtory of animal ſubſtances, follows a courſe ſimilar to that of the preceding, on account of the analogy which exiſts between theſe ſubſtances and vegetable matters. It is divided into no more than four orders of facts inſtead of ſix, becauſe the animal analyſis, though greatly advanced during the laſt twenty years, and though here treated with details, and in a method which I think I may affirm to have been entirely unknown before, does not preſent a ſeries of diſcoveries and of facts ſo complete as that of vegetable ſubſtances.

The firſt order of facts, which contains generalities concerning the anatomical ſtructure and chemical compoſition of animals, treats, in four articles, of the whole of their organs, of the functions which they exerciſe, of the hiſtory of the chemical diſcoveries to which they have given riſe, and of the new data which modern analyſis has furniſhed concerning the conſtituent elements of animal compounds.

In the ſecond order of facts, I deſcribe the chemical properties of animal compounds in general, or the manner in which theſe compounds are affected by the principal agents of chemiſtry. This is one of the neweſt parts of the whole, and one of thoſe which I have treated with the greateſt care, as well on account of its importance, as of the novelty of the ſubject.

This order of facts is divided into ten articles. After the general conſiderations concerning the principles of animal chemiſtry, which compoſe the firſt of theſe articles, I explain in the ſecond, the action of caloric on the animal compound, and I compare it with what the vegetable matter undergoes. Much fætor in the products, a thick and abundant oil, concrete carbonate of ammonia, and two or three other ammoniacal ſalts, carbonated and ſulphurated hidrogen gas, a charcoal denſe and difficult to burn, and charged with phoſphate: theſe characterize the animal compound.

The actions of air and water on the ſame compound are explained in the IIId and IVth articles; and its alteration by theſe agents, ſo totally different from that of the vegetable compound, ſhews a diſtinctive character which, as well as the facts announced in the preceding article, depends on the preſence of azote and the ſuperabundance of hidrogen.

The Vth article conſiders the action of the acids on animal matters; I there ſhow that that action is the moſt definite and the moſt remarkable character of theſe ſubſtances. The alteration and decompoſitions which they undergo by the nitric acid principally occupies this article.

I ſhow in what manner the animal compounds are changed by that acid into azotic gas, into carbonic acid gas and pruſſic acid, into water, into ammonia, into fat, into a bitter yellow matter, and into the oxalic and acetous acids. The action of the other acids is not overlooked, though infinitely leſs important than that of the nitric acid, in explaining the properties, the characters, and the compoſition of animal ſubſtances.

In the VIth article, I trace the action of the pure alkalis on theſe ſubſtances; I prove that the alkalis by diſſolving them convert a portion into ammonia which is volatilized, and into oil which forms a ſoap with them. I ſhow that it is on this that the very active energy of the alkalis upon the animal compound depends, and that this energy ſerves alſo to explain the nature and the difference of its compoſition.

In the VIIth article, I examine the action of the ſalts, of the oxides, and of the metallic ſolutions on the animal compound; I ſhow how the firſt preſerve, and how the ſecond deſtroy it.

In the VIIIth article, I explain the mode of action of vegetable ſubſtances on that compound, and though it is much varied on account of the difference of theſe ſubſtances, I deduce from it a generic and diſtinctive character of animal matter.

Article IXth. By preſenting the formation of the pruſſic acid as one of the moſt characteriſtic properties of the animal compound, I generalize the production of the animal acids as a phenomenon which it is of importance to ſtudy in the animal compound.

The ſame is the caſe with putrefaction, the ſubject of the Xth and laſt article of the ſecond order of facts. Admitted long ago as the moſt definite character of animal compounds, this ſpontaneous decompoſition is at preſent much better known as to its cauſe, its phenomena, and its products than it formerly was; and I have attempted, after my own obſervations, to give a more accurate, though much more preciſe hiſtory, than has hitherto been made.

The third order of facts belonging to this part of chemiſtry, comprehends the examination of the chemical properties of animal ſubſtances in particular. It anſwers to that of the preceding ſection, in which I have placed the hiſtory of the immediate materials of vegetables. This is the longeſt and the moſt detailed of the orders of this eighth ſection, becauſe it is appropriated to the treatment of animal matters ſeparate from each other: accordingly, it contains thirty-four articles, of which ſeveral are more extenſive than any of the two preceding orders.

After having treated, in the firſt article, on the different modes of claſſing animal matters, I give a table in which I divide them methodically with regard to their origin, their regions, and their uſes.

In the ſecond article, I give the chemical hiſtory of blood; I divide that article, on account of the importance of its ſubject, into nine paragraphs, where I ſucceſſively conſider, 1ſt, the hiſtory of the analyſis of blood; 2d, its general properties; 3d, its ſeparation into ſeveral immediate materials; 4th, the ſerum; 5th, the coagulum or cruor; 6th, its colouring part; 7th, its fibrous part; 8th, its differences or variations; 9th, the changes of which it is ſuſceptible. Under theſe nine titles are compriſed all the facts at preſent known concerning this vital liquid, and all the new truths afforded by chemiſtry, which might be ſought for in vain in any other ſyſtematic work.

The third article is confined to the lymph, which is little known.

The fourth, to fat and the ſebacic acid, the properties and nature of which begin to throw much light on animal phyſics.

The fifth, to the humour of tranſpiration, of ſweat, and of the interior cavities, concerning which we have but few notions, though indeed much more preciſe than we had of them formerly.

The ſixth, to ſynovia, a matter yet little treated of.

The ſeventh, to the cellular, membranous, tendonous, ligamentous textures, all approximating to each other by the gelatine which they equally furniſh by the aid of water, and differing only in their form and their denſity.

The eighth, to the muſcular or fleſhy texture, preſenting in its irritable parenchyma, deprived of whatever acceſſories it contains, the fibrous matter which the blood there depoſits.

The ninth, to the texture of the dermis and epidermis, analogous, under certain relations, to the membranous texture, but differing from it in ſome properties which form the ſubject of this article.

The tenth, to the horny texture of the down, of the hair and of the nails, very little examined by chemiſts, but which merits all their attention.

The eleventh, to the cartilaginous texture, a ſpecies of half ſolid, elaſtic matter which has not yet been ſtudied chemically.

The twelfth, to the oſſeous texture, concerning which the diſcoveries of Scheele and of the chemiſts who have proſecuted his original reſearches, have diſcovered facts entirely unknown till their time, and calculated to throw a ſtrong light on the functions and diſeaſes of the bones.

The eleven firſt articles of the IIId order comprehend all together the matters which belong to the whole body of animals, which are found in every region, and which conſtitute their general organization. In the twenty-two following are placed the particular matters which exiſt in the cranium, in the different regions of the face, in the thorax and in the abdominal cavity.

The thirteenth article treats, in four paragraphs, on the cerebral and nervous pulp, of the nervous fluid, of the liquor of the ventricles of the brain and of the concretions of the pineal gland, matters of which no chemiſt has yet either attempted the examination, or indicated the properties.

The fourteenth of the aqueous, vitreous, cryſtalline humours and of tears, alſo omitted in the arrangements of the chemiſts.

The fifteenth, of the naſal mucus.

The ſixteenth, of the humours of the mouth, principally of the ſaliva, of the ſalivary calculus, and of the tartar of the teeth.

The ſeventeenth, of the wax of the ears.

The eighteenth, of the tracheal and broncheal humours, of the pulmonary gas and concretions. All theſe animal humours have been paſſed over almoſt in ſilence in the treatiſes of chemiſtry. The accounts given of them by phyſiologiſts have been moſt commonly filled with errors and inaccuracies: and though what I deliver is not the product of reſearches ſufficiently completed, nor of experiments ſufficiently numerous and definite, theſe articles are diſtinguiſhed from what has hitherto been written, not only becauſe I have confined myſelf to certain facts or definite analogies, but alſo becauſe many of theſe humours have been the ſubjects of reſearches more or leſs conſiderable, undertaken, as well by myſelf in particular, as by my pupil and friend Citizen Vauquelin.

The ſubject of the nineteenth article, which is very different from thoſe of the ſix preceding articles, has afforded me the aſſiſtance of a great number of reſearches, made by many able men, becauſe it treats of the well known and much uſed animal liquor, milk. I had only to chooſe among the numerous reſults which the hiſtory of the ſcience preſented to me. This article nevertheleſs contains a ſeries of facts which are due to me. I have divided it into eight paragraphs, in which I have ſucceſſively examined, 1ſt, the natural hiſtory and the formation of milk; 2d, its phyſical properties; 3d, the chemical analyſis of milk intire; 4th, that of ſerum or ſkimmed milk; 5th, the caſeous matter; 6th, the buttery ſubſtance; 7th, the different ſpecies of milks employed; 8th, laſtly, the economical and medicinal uſes of that liquid.

In the XXth article, I begin the examination of the animal matters belonging to the abdominal region with that of the gaſtric and pancreatic juices, liquids concerning which a great many fabulous accounts have been given, and the former of which only began within a few years to be ſubmitted to a ſeries of experimental reſearches.

The XXIſt article treats of the bile; this is one of the animal humours, which is leaſt known. I have divided its hiſtory into ſeven paragraphs; namely, 1ſt, the ſecretion of the bile; 2d, its phyſical properties; 3d, its chemical properties; 4th, examination of its different conſtituent materials, ſingly conſidered; 5th, the varieties of the bile in different animals; 6th, its uſes in the animal economy; 7th, laſtly, its medicinal and economical uſes. Here, as in all the other articles relative to animal chemiſtry, while I have related whatever chemiſts have ſaid concerning the bile, I have alſo detailed the reſults of my particular reſearches, and have ſhown of how great uſe the exact knowledge of this liquid is to phyſiology and to pathology. I have particularly inſiſted on the concreſcible oil and the bitter colouring matter of the bile, as well as on the ſalts it holds in ſolution, and the variety of ſtates which it preſents.

The XXIId article, which treats of the biliary calculi, may be regarded as entirely new, becauſe chemiſts have written ſcarcely any thing concerning it hitherto, and becauſe they have been the ſubject of ſeveral diſcoveries peculiar to myſelf. From their well known nature, determined by my analyſis, I have derived a method of claſſing theſe concretions, with other important conſiderations reſpecting their cauſe, their formation and their treatment.

In the XXIIId article, I ſpeak of certain matters belonging to the inteſtines and yet very little known, ſuch as the inteſtinal humour, the chyle, the excrements, the inteſtinal gas and calculi. I do not forget to ſtate the utility and importance of reſearches made on theſe ſubſtances.

In the XXIVth article I have combined whatever is at preſent known concerning certain liquors peculiar to the fœtus, ſuch as the liquor of the amnios, the cutaneous covering which envelops it, the ſubrenal humour and the meconium. There is none of theſe liquids which may not become the ſubject of valuable experiments, if we may form a judgment from what has juſt been diſcovered by Citizens Vauquelin and Buniva concerning the liquor of the amnios. I have given in detail the hiſtory of this laſt diſcovery.

The XXVth article contains the chemical examination of urine. The importance of this part of animal chemiſtry, the numerous reſearches of which it has been the ſubject during a century, the diſcoveries which it has given an opportunity to Citizen Vauquelin and myſelf to make, and particularly the grand applications of theſe diſcoveries to animal phyſics, have engaged me to treat of this liquor with all the extent it requires. I have divided this article into ſix paragraphs, which treat, 1ſt, of the formation of urine; 2d, of its phyſical properties; 3d, of the hiſtory of the ſucceſſive diſcoveries to which it has given birth; 4th, of its chemical properties and of its analyſis; 5th, of the matters which are contained in it, conſidered particularly after each other; 6th, of the *urée*, a name which I have given to a ſubſtance different from every other animal matter, and which characteriſes urine; 7th, concerning the varieties of that liquid in the different circumſtances of life; 8th, its differences in animals; 9th, application of the new chemical facts which relate to it, to the philoſophy of the human ſtructure; 10th, laſtly, concerning its medicinal, chemical and economical uſes. In this methodical arrangement, all the notions at preſent acquired concerning urine are included; and, by reading it with proper attention, the ſtudent will ſoon diſcover that no ſubſtance is better entitled to the attention of philoſophers than this ſingular product of animalization, deſtined, when it ſhall be ſtudied with all the care which it deſerves, to afford a ſolution of the moſt difficult problems of phyſiology and the art of healing.

The ſame obſervations apply to the XXVIth article, which comprehends the chemical hiſtory of human urinary calculi. The number and importance of the new facts which their analyſis has preſented to Citizen Vauquelin and myſelf, have induced me to divide this article into eight paragraphs. I there conſider ſucceſſively, 1ſt, what has been done already concerning theſe concretions; 2d, their ſituation and phyſical properties; 3d, their different conſtituent materials; 4th, their claſſification according to their nature; 5th, the cauſes of their formation; 6th, their ſolvents or the lithontriptics; 7th, the urinary calculi of animals; 8th, the arthritic concretions of man, the relations of which with the urinary calculi have for ſo long a time engaged phyſicians. This article, one of the moſt original in the book, is particularly adapted to ſhew the great influence which chemical analyſis ought to have on the problems of the animal economy.

The XXVIIth article treats of the liquor of the proſtata, which has not yet been analyſed, and of the ſpermatic liquor, concerning which

Citizen Vauquelin has publiſhed a very intereſting work, though its reſults do not yet give any light that can enable us to conceive the myſtery of generation.

The XXVIII, XXIX, XXX, XXXI, XXXII, XXXIII, and XXXIVth articles, which terminate the third order of this ſection, are employed on the explanation of ſome peculiar animal matters, which medicine and the arts extract from mammiferous animals, birds, reptiles, fiſhes, molluſca, inſects, worms and zoophytes. From ivory to the ſponge, forty animal ſubſtances, derived from different claſſes of animals, are preſented in this article, treated rapidly, and compared with thoſe which are analogous to them in the body of man.

The fourth and laſt order of facts of the eighth ſection has for its object one of the moſt valuable applications of chemiſtry—that which, reſulting from all the preceding details, is calculated to enlighten animal phyſics. Under the title of the chemical phenomena which living animals preſent, I have not intended to treat of the whole of phyſiology; I have only been deſirous of ſhowing what light chemiſtry can afford for the knowledge of the animal functions, to prove the indiſpenſable neceſſity of its aſſiſtance in theſe reſearches, and I have treated in twelve articles the generalities of its applications.

In the firſt, I explain the exiſtence of the chemical phenomena in the life of animals.

In the ſecond, I deſcribe the phenomena of this kind which take place in reſpiration, that of the functions in which they have been evidently obſerved and better deſcribed in conſequence of the modern diſcoveries.

In the third, I treat of thoſe which take place in circulation; the nature and changes of the blood in the different regions, particularly in the arterial and veinous ſyſtems, more eſpecially engage the preſent article.

In the fourth, I conſider the chemiſtry of digeſtion, and ſhow that this ſcience alone can exactly and completely explain its true mechaniſm.

The fifth article treats of ſecretion and tranſpiration. The hiſtory of this laſt preſents, when chemically conſidered, reſults which are very new and very different from what has hitherto been ſtated reſpecting it.

The ſixth article ſhows the chemical phenomena of nutrition, which in effect conſiſts in an appropriation and concretion of the liquids conveyed in each organ.

The ſeventh ſhows that the exerciſe of the muſcular irritability may very well depend on a chemical power, and begins to diſſipate at leaſt the hitherto impenetrable obſcurity of that function which is ſtill ſo little known.

The eighth, in treating of ſenſibility and of the principal function of the nerves and of the brain, proves that many data are ſtill wanting to enable us to conceive its mechaniſm.

The ſame concluſion is found in the IXth article, relative to generation.

This however is not the caſe with oſſification, the ſubject of the tenth article. The analyſis of bone, ſo well made at preſent, throws a very ſtrong light on this function as well as on the diſeaſes of the organs which execute it. I have been particularly careful of this article, on account of the intereſt which it excites and the new proſpects to which it has given birth.

In the eleventh article, I have ſketched the difference which the diverſity of the ſtructure of animals produces in the chemical phenomena. It has ſeemed uſeful to me to ſhow that the organs, differently conſtituted in the different claſſes of animals, muſt cauſe modifications in the chemical phenomena which accompany their life, and depend upon or ſupport it.

Laſtly, the object of the twelfth and laſt article has for its aim to prove that there exiſts, in diſeaſes, chemical-phenomena, the ſtudy of which may enlighten our knowledge of the nature, the cauſes, and conſequently of the treatment of theſe affections.

This article, the 8th and laſt ſection of the work, ſerves to announce how greatly Animal Chemiſtry, to which, for a number of years, I have paid the moſt profound attention, is advanced, and how much this preſent treatiſe goes beyond every other which has yet been publiſhed.

SUCH is the method which I have followed in the work now preſented to the world; and, on reading with attention the eight notices which precede it, and reflecting on the courſe I have followed, it will be found that my intention has been,

1. To unite a greater number of chemical facts together than has yet been collected in any work which has come to my knowledge.

2. To preſent them with all the proofs and all the developments of which they are ſuſceptible.

3. But nevertheleſs to preſent them almoſt independent of the connected and analytical hiſtory of thoſe diſcoveries which have given them to philoſophers; or of the practical and experimental manipulation, by means of which they may be reproduced, or the applications which may be made of them to ſciences and the arts.

4. By theſe means, to detach the theoretic part of the ſcience from its hiſtory, its practice, and its applications; or, at leaſt, to borrow nothing from either of thoſe parts of chemiſtry conſidered in its totality, except what may have appeared to me to be indiſpenſably neceſſary, either for properly apprehending this theory, or to ſhow its progreſs, its proceſſes and its uſeful objects.

5. To diſpoſe thoſe facts, or chemical truths, in a new order;—not that of the naturaliſts, nor any order borrowed from the other ſciences,

arts, or even collection of arts; however copious the means of ſuch arts may be.

6. To eſtabliſh, by this means, a new order naturally chemical;—an aſſemblage of which all the parts ſhall be intimately connected with each other. And, for this reaſon, I have entitled my treatiſe, A SYSTEM OF CHEMICAL KNOWLEDGE.

7. But nevertheleſs, to ſhow the ſcience in its greateſt latitude, in all its ſublimity, making its way, as it were, by the aſſiſtance of that genius which has created it, and which aggrandizes it daily beyond moſt other ſciences, and enlightening them by its luminous conſequences; for which reaſon I have added to the title, A SYSTEM OF CHEMICAL KNOWLEDGE, the words, AND ITS APPLICATION TO THE PHENOMENA OF NATURE AND OF ART, in order to ſhow that this ſcience conſiders equally that which paſſes in the great laboratories of the atmoſphere, in the waters and in ſubterraneous cavities; among minerals, among vegetables and among animals; as well as that which is performed on all the natural productions in the workſhops of the arts.

8. And, laſtly, to ſhow how far the human mind, aſſiſted by all the inſtruments and all the machines which the art of experimenting has created for more than a century paſt, has advanced in the determination of effects and the changes which all bodies undergo from the na-

tural effort which impels their particles towards each other.

9. To accompliſh this plan to the utmoſt extent which my means, my faculties, and my zeal for the progreſs of chemical ſcience have allowed, the reader will be miſtaken if he ſhould apprehend that I have limited myſelf to collect the materials contained in ſuch works as have preceded this. I have certainly neglected none of the abundant ſources which the writers of chemiſtry have laid open; more eſpecially during the courſe of the 18th century. I have not omitted to conſult the authors of preceding times, though I have found in them much leſs of accurate reſult than in the works of my contemporaries. Theſe laſt, and more eſpecially my own countrymen, who have done ſo much during the laſt fifty years for the advancement of chemiſtry, have more particularly ſupplied me with a great number of truths; and without their efforts it would have been impoſſible for me to have formed even an idea of my ſyſtem. But this treatiſe does not reſemble a great number of thoſe which are confined to the ſtudy or demonſtration of the elements of ſcience. It muſt not be confounded with mere compilations; however great the merit and the talent required in their authors for this kind of work, when they render the materials their own by the connection of ideas with method and the mutual elucidation of facts. I muſt even ſay, that, in many reſpects, the greater number of the

chemical truths exhibited in this ſyſtem are my own; either on account of the diſcovery of the facts they exhibit, the manner in which I have reviewed or conſidered them, or the new reſults which I have obſerved in moſt of thoſe which had been before diſcovered. That indifference which ſome men of merit are too much diſpoſed to ſhow for elementary or ſyſtematic works, the haſty and often too ſevere judgment which they deliver on thoſe productions by conſidering them as collections of facts already known;—the method, which ſome men ſtill more unjuſt have adopted, of borrowing from treatiſes more or leſs complete, paſſages which they afterwards offer as original; and ſtill more, the liberty which ſo many pupils take, either by unconſcious recollection or decided illiberality, to appropriate to themſelves thoſe facts which are preſented in public or private lectures, without quoting the ſource to which they are indebted, oblige me to declare in this place, that my ſyſtem includes a ſeries of diſcoveries and obſervations which are my own, whether they be extracted from memoirs which have been already publiſhed, or whether inſerted for the firſt time in this work. The uninterrupted labour of twenty-five years, a great number of connected reſearches upon the alkalis, ſalts, mineral waters, metallic ſolutions, vegetable matters, and more eſpecially animal ſubſtances, and the perpetual opportunities which have offered of repeating former experiments, and modifying them in many different ways, have led me to a great number of diſcoveries, and the learned world has already been enabled to judge of the new manner in which thoſe labours have allowed me to modify the Elements of Chemiſtry, of which the laſt edition was publiſhed eight years ago.

It is not therefore alone by the courſe or method, though indeed, entirely different from thoſe which have hitherto been adopted in works of chemiſtry, that my ſyſtem of chemical knowledge ought to be characterized. Neither ought it to be conſidered merely as a more extended and complete collection of chemical facts. The attention of the reader muſt alſo be directed to a number of new truths, of facts hitherto unknown, and diſcoveries which belong to myſelf. In order to ſecure this property in the region of chemical facts, I might give an extended liſt of all the memoirs which I have not ceaſed to publiſh during twenty years; in the volumes of the Academy of Sciences, the Society of Medicine, the Annals of Chemiſtry, *La Medicine Eclairée*, and various other national or foreign collections. But this exhibition is not neceſſary for thoſe who are attached to the ſciences, and look every where for new productions. I have alſo announced, at leaſt, in part in the preceding notices, what appertains to myſelf in each article. It will be ſufficient, in order to afford a better judgment on the nature of the preſent work and to remove or weaken the notion of mere compilation which many readers adopt on the ſimple title of a ſyſtematical treatiſe, to remark, that the preſent contains a great number of things which are peculiarly my own, and which have never yet been mentioned in any work.

Twenty-five years of ſtudy, and of continued labour without interruption, have enabled me to collect the materials of this ſyſtem of chemical knowledge. I have been employed in drawing it up ſince the year 1793; part was written during the times of public misfortune and proſcription, of which it ſerved to ſoften the hardſhips. While my country, a prey to Vandaliſm and tyranny, beheld its citizens oppreſſed beneath the yoke of a deſpotiſm, the more horrible as it affected the forms and the inſignia of liberty;—when every heart cloſed to ſocial enjoyment, and almoſt to the hope of better proſpects, refuſed even this laſt comfort of the unhappy, I was almoſt inſenſible of the weight of public diſtreſs in the charms of ſtudy and of ſolitary exertion. A ſtranger to the parties, to the factions, which deſolated the riſing republic, and ſo often placed it in danger of periſhing; in the midſt of tumult and civil diſcord; occupying, contrary to my inclination, a place in which a man of principles could only lament the inſufficiency of his means, and in which talents, virtue, courage, uſeleſs to the public welfare, had no other reſource to eſcape the effect of the moſt atrocious paſſions than to conceal themſelves,

ſelves. Alone, and inſulated in the midſt of the agitated and noiſy crowd, with which I was ſurrounded, I comforted myſelf in ſome meaſure, and weakened the ſtrong ſentiment of public, miſery by fixing my attention on the production of the preſent ſyſtem.

The leſs unhappy times which ſucceeded the fortunate epoch of the 10th Thermidor, in the year 2, allowed me to work with greater ardour and aſſiduity upon this treatiſe. I finiſhed it in the laſt two years of liberty, which my quitting the legiſlative body allowed me.

At length, the 18th Brumaire ſhone forth upon France. The impreſſion of this work, which was already begun, but had been interrupted for ſome months on account of difficult circumſtances, then reſumed a new activity. This great undertaking, namely, the publication of ten volumes in octavo and five in quarto, of which few perſons know how to eſtimate the difficulties, was terminated with courage and conduct as well as with ſagacity, by the printer who undertook it. A witneſs to the exertions he was obliged to make, as well as thoſe which he does not ceaſe to make for the memoirs of the Inſtitute, I muſt do Citizen Bauduoin, who has connected his proſpects with the fate of my work, the juſtice to obſerve, that he has not been diſcouraged by any of the difficult circumſtances which have impeded him more than once; but that ſuperior to obſtacles of more than one kind, he has ſurmounted them by his activity and his knowledge in typography.

My ſyſtem appears at a period which ſhall be renowned in the annals of the world. The laſt days of the eighteenth century are come. The ſpirits of men, awakened by luminous works which have illuſtrated every branch of human knowledge and more particularly natural ſcience, are now directed to new and more elevated conceptions. A new order of things is prepared for the nineteeth century which has now advanced. The nations more advanced in civilization, appear diſpoſed to great changes which muſt ameliorate their fate. The terrible experiment which France has made during ten years of revolution; the dreadful events of which that land has been the theatre; the errors ſhe has committed and which have torn her vitals,—will ſerve as an example and leſſon for the reſt of Europe. Inſtructed by the ſacrifices which the conqueſt of her liberty has coſt her, other nations will repreſs the dreadful paſſions of which France has been the victim. They will not ſuffer themſelves to be deſtroyed by factions. They will avoid thoſe outrages which have ſo often brought us to the brink of deſtruction. They will apply to the acquiſitions of knowledge, the influence of philoſophy and the clear light of reaſon; and they will apply thoſe energies alone to the perfection of civil ſociety and the advancement of human intelligence.

The hero whom France has choſen for the chief of her government, ſhall eſtabliſh her repoſe and dignity, by the power of his genius. His labours for her proſperity ; the liberal principles which direct his plans, will convey to the whole world, by the glory of his name and the wiſdom of his adminiſtration, that image of happineſs to which nations may arrive when their governors poſſeſs elevation of mind, the power of knowledge, the energy of courage, purity of manners, and the love of every thing which is elevated and admirable.

Peace will ſpeedily cloſe the wounds which a cruel war has made on humanity. Soon will the conſolation of the arts repair the evils and obliterate the calamities which have oppreſſed Europe for ten years. The ſciences, after reſiſting all the diſaſters of war under which they have languiſhed, will reſume new activity. Chemiſtry, which at preſent compoſes ſo extenſive a part of theſe ſciences, will continue to be cultivated with increaſing ardour. France the land in which her growth has been ſo rapid ;—which has for the laſt twenty-five years been more particularly her reſidence—France which to every other deſcription of fame, adds that of having renewed and reformed this ſcience ſo uſeful to man, will be careful to preſerve the ſuperiority ſhe has aſſumed in its cultivation. Chemiſtry which has now become an eſſential part of the objects taught in all the ſchools, will gradually extend itſelf through all the claſſes of ſociety, and while advances of this ſcience towards perfection, by the diſcoveries of learned men, ſhall proceed with unabated rapidity, it will give additional light to all the manufactures and works of which the proſperity is ſo intimately connected with its progreſs.

A
SYSTEM
OF
CHEMICAL KNOWLEDGE.

SECTION FIRST.

The firſt Principles of Chemical Science, Generalities, and Introduction.

ARTICLE I.

Definition of Chemiſtry; its various Denominations; its Relations and Differences with Regard to the other Sciences.

1. THE true etymology and origin of the word Chemiſtry is abſolutely unknown. Both are enveloped in myſtery, and loſt in the darkneſs of ages paſt. Some hiſtorians of this ſcience ſuppoſe its name to be derived from the word *Kema*, the pretended book of ſecrets, entruſted to women by the demons; others derive it from Cham, the ſon of Noah, from whom

Egypt received the name Chémia, or Chamia; ſome attribute it to Chemnis, king of the Egyptians; and others deduce it from the word χύμος, (humor) which ſignifies juice, becauſe they ſuppoſe it to have commenced with the art of preparing juices, or from the other Greek word χέω, χύω, (fundo) I melt; becauſe, according to them, it is the daughter of the art of ſmelting the metals.

2. Chemiſtry has alſo been denominated the Hermetic art or ſcience, becauſe its origin is attributed to the wiſe Egyptian HERMES: or *alchemy*, when it is made to conſiſt in the ſearch after the art of producing gold; for the ſame reaſon it is likewiſe called *chryſopeia*, and *argyropeia*; *pyrotechny*, becauſe much uſe is made of fire, the effect of which it ſhows how to direct; the *ſpagyric* art, derived from two Greek words, one of which ſignifies to ſeparate, and the other to unite again, becauſe, in fact, it ſeparates and re-unites the elements of bodies.

3. Authors have been almoſt as much at variance with reſpect to the definition as to the origin and etymology of chemiſtry. Some have confined it only to the art of examining, extracting and purifying bodies, particularly metals; others have only conſidered it as that of preparing remedies. It is only ſince the middle of the eighteenth century that Chemiſtry has been conſidered as the ſcience which aſcertains the principles of which bodies are

compoſed, and their different nature. But even this laſt definition is not accurate, becauſe it neither compriſes all the productions of nature, the principles of ſome of which are unknown, nor all the means of the ſcience, which are not confined merely to the ſeparation of the conſtituent parts of bodies.

4. The true definition which ought to be given, in the preſent ſtate of the ſcience, is much more general. The following is what I have adopted for the laſt twenty years. Chemiſtry is a ſcience by which we become acquainted with the intimate and reciprocal action of all the bodies in nature, upon each other. By the words *intimate* and reciprocal *action,* the ſcience is diſtinguiſhed from experimental philoſophy, which only conſiders the exterior properties of bodies, poſſeſſing a bulk or maſs capable of being meaſured, whereas chemiſtry relates only to the interior properties, and its action is confined to particles whoſe bulk and maſs cannot be ſubjected to admeaſurement and calculation.

5. Chemiſtry is a ſcience diſtinct and ſeparate from all others; it can no longer be confounded with alchemy, which, even if ſucceſsful, would be only one of its experiments; nor with metallurgy, which is but a chemical art; nor with pharmacy, which is only one of its branches; nor with natural philoſophy, which ought to precede its inquiries, without the being able to direct its cauſe; nor with medicine,

which derives from it much information, but merely with a view to apply it to animal phyſics, and the action of all bodies upon that of man and animals ; nor, in ſhort, can it be confounded with any art, however ingenious and extenſive in its means and reſults. The ſcience of chemiſtry may, and actually does, enlighten all the natural ſciences, and all the proceſſes of manufacture, purification, and extraction, practiſed in the arts, by which the intimate properties of natural ſubſtances are modified.

6. Its manifeſt aim, in inveſtigating the intimate mode of action exerciſed by the particles of different bodies upon each other, is to determine the reſult of that action, the changes which it produces in the properties of bodies, the quantity, the proportion, the order of combination of the different elements which conſtitute the natural compounds, the manner of acquiring a perfect knowledge of their compoſition, the different degrees of force with which the various bodies tend to combine, or have been united by nature, and on acquiring theſe firſt reſults to enable the philoſopher to ſeize the true diſtinctive characters of the productions of nature, the manner in which they are formed, deſtroyed, and changed in the phenomena of our globe, as well as the numerous reſources which they afford to ſatisfy the wants of man ; from thoſe which are indiſpenſable to the ſupport of his exiſtence, to thoſe others invented by the efforts of genius, to the advancement

of human reaſon, and the enjoyments of civilized life.

Article II.

Diviſions and Branches of Chemiſtry.

1. SINCE chemiſtry has become applicable to moſt of the arts and ſciences, and capable of extending their limits, ſince its ſphere has been enlarged, and its dominion aggrandized by the modern diſcoveries, the neceſſity has been felt of particularly conſidering its different branches, and of dividing them into ſeveral departments, which, without forming ſeparate or inſulated ſciences, have the advantage of preſenting a variety of applications, and of exhibiting its whole utility at the ſame time.

2. It is now no longer a queſtion whether this ſcience ſhould be divided only into theoretical and practical chemiſtry; a diſtinction which formerly was the only one admitted, which was even the natural diviſion of the moſt eſtimable works on chemiſtry, particularly thoſe of Boerhaave, Senac, and Macquer. Such a diviſion is more detrimental than uſeful to the progreſs of ſcience; as it tends to ſeparate parts which ought to remain inſeparable. Theory, without practice would proceed, as it were, blindfold, while practice without conducing to theory, would be only a vain manœuvre, without any effectual object.

3. In the preſent advanced ſtate of the ſcience I diſtinguiſh eight principal branches of chemiſtry, which, by compriſing the whole ſubject, afford at once the exact outline and the whole of its details. Theſe eight branches are philoſophical chemiſtry, meteorological chemiſtry, mineral chemiſtry, vegetable chemiſtry, animal chemiſtry, pharmacological chemiſtry, manufacturing chemiſtry, and economical chemiſtry. By defining each of theſe branches, it will be ſeen that though they are connected by an indiſſoluble chain, it is nevertheleſs neceſſary, in order to carry each to perfection, that they ſhould be cultivated apart.

4. *Philoſophical Chemiſtry* precedes and governs all the other branches. By means of the moſt general facts, it eſtabliſhes the principles and lays the foundation for the whole doctrine of the ſcience. It is not applicable to any particular object, but it illuminates them all: it treats of the laws of attraction between all ſubſtances, the phenomena of their combinations or their decompoſitions, the properties of the principal bodies or thoſe moſt generally diſperſed through nature, the operations which are performed for diſcovering the mutual action of all bodies, and the general means of analyſing or combining them: it explains the moſt important motions in nature; and derives from all the other branches thoſe facts by which it is conſtituted. With reſpect to the other ſeven branches, it forms the primitive trunk by which

the whole is ſupported; in ſhort, it has the ſame relation to the other branches, as ſimple mathematics bear to their applications.

5. Meteorological chemiſtry relates particularly to all the phenomena which take place in the air, and are known under the name of meteors. No author has hitherto ſpoken of this ſpecies of chemiſtry, and it has been formed only a few years. Phyſical obſervation alone is not ſufficient to aſcertain the nature, or even the phenomena, the ſucceſſion, and particularly the cauſe of meteors. Why the immenſe volumes of meteorological obſervations which overload our libraries, ſhould contain no information of importance to mankind relative to the grand effects produced in the atmoſphere, can no otherwiſe be explained but by admitting that the true path for reſolving theſe moſt elevated problems has not hitherto been followed. Meteors are truly chemical effects: inflammable, luminous, aërial, aqueous, or whatever character they may poſſeſs, under whatever form they may appear, whatever may be the matter they affect, tranſport, or change, they are evidently to be attributed to immenſe chemical operations; and chemiſtry alone is capable of unveiling their cauſe and penetrating their myſteries. The ſummits of high mountains and aeroſtatic machines will ſooner or later be the laboratories where new experiments and new inſtruments will be introduced to inveſtigate the nature of theſe terrible atmoſpheric revolutions,

of which man, after having long dreaded their effects, is now called upon to inveſtigate the cauſes, in order to prevent or obviate their deſtructive influence.

6. The object of *Mineral Chemiſtry* is to analize and examine all kinds of foſſils, waters, earths, ſtones, metals, bitumens, &c.; it is the art of ſeparating, combining, and purifying them, of aſcertaining their decided characters, their primitive form, their various ſtates, and their different and ſucceſſive alterations. It is this branch which directs the inquiries and claſſifications of mineralogiſts; without this there could be no mineralogy; and it may at ſome future period be capable of explaining the revolutions of the globe, and laying a real foundation for the infant ſcience of geology. It explains the formation of ſtones, minerals, depoſitions, incruſtations, ſtalactites, the action of ſuperficial or ſubterraneous waters, of volcanic eruptions, of earthquakes, depreſſions of the earth, &c. This is one of the moſt cultivated and advanced branches of chemical ſcience.

7. *Vegetable Chemiſtry* treats of the analyſis of plants and their products. A ſhort time ago, it conſiſted only of a ſeries of the proceſſes of thoſe arts which extract, purify, and appropriate to our wants, the different materials of vegetables, or prepare them in different ways for the relief of our infirmities. At preſent its object is more extenſive, its ſubject more enlarged, and its views in ſome degree more elevated,

vated. It poſſeſſes new methods of decompoſing the products of plants, and of aſcertaining the order of their compoſitions: it begins by explaining their intimate nature, their formation and connection; it effects changes in them ſimilar to thoſe produced by vegetation; and it will ultimately ſucceed in explaining the laws of vegetable economy, the moſt ſolid and the only baſes of which it has already eſtabliſhed. It exhibits the manner in which mineral ſubſtances unite in triple compounds to form vegetable ſubſtances, the influence of different ſoils, that of the mixture of earths, of compoſts, and of irrigation upon vegetation. Its early ſucceſs announces that it will at ſome future period conſtitute the foundation of agriculture, as it has long been the guide of the apothecary, and of all the arts which have for their object the treatment of vegetable ſubſtances.

8. *Animal Chemiſtry* is at preſent in the ſame promiſing ſituation as vegetable chemiſtry. Like the latter, it is not confined to the analyſis of the materials of animal bodies, and the advancement of the arts which prepare thoſe materials for our wants. Its deſtination is more elevated, and its views much more extenſive. Provided with exact inſtruments, and ingenious methods for determining the real difference which exiſts between vegetable and animal ſubſtances; it ſhows the circumſtances that take place in the former, when they paſs to the ſtate of the latter in the organs of animals; it ex-

plains the effects of digeſtion, reſpiration, tranſpiration, and ſeveral other functions of the animal economy; it opens a new field for the philoſophy of organized and ſenſible bodies; its object is alſo to aſſiſt anatomy, in eſtabliſhing baſes of phyſiology on more certain information. It is already, we have reaſon to think, on the point of explaining the phenomena of vitality and irritability. By this branch of ſcience alone, we ſhall be able to determine the morbific alterations in the animal fluids and ſolids, and, by this means, to lay a real foundation to pathology. This department of chemiſtry will alone be capable of explaining the effects of a great number of remedies: hence, having become medicinal in the ſcience of the human frame in a ſtate of diſeaſe, it muſt be divided into three ſecondary branches, viz. phyſiological chemiſtry, pathological chemiſtry, and therapeutical chemiſtry.

9. *Pharmacological Chemiſtry*, which compriſes all that relates to the knowledge, the preparation, and the adminiſtration of medicines, is one of thoſe branches that has moſt contributed to the eſtabliſhment of philoſophical chemiſtry, on account of the great number of experiments and trials it has given occaſion to be made on all the natural bodies. While this branch has riſen to the moſt ſublime conceptions, and the moſt elevated applications, pharmacological chemiſtry, enlarged even by the reſults of the former, has ſo multiplied its

means and reſources, that it has become one of the moſt important branches of the ſcience. It treats of the analyſis of ſimple medicines, the preparation of chemical remedies, the compoſition of galenicals, and magiſtral compounds, which are daily varied by the art of formulæ; the preſervation of ſimple and compound medicines, as well as the detection and prevention of adulterations.

10. I call that by the name of *Manufacturing Chemiſtry*, which is applied to diſcovering, rectifying, extending, completing, or ſimplifying the chemical proceſſes of manufactures. To obtain ſucceſs, it is neceſſary to join a ſpirit of invention to the moſt profound knowledge of philoſophical chemiſtry. In France it has made a very rapid progreſs during ſeveral years, which is proved by the numerous eſtabliſhments for bleaching, for the manufacture of printed goods, for dyeing, ſope-making, tanning, the making of ſalts and mineral acids, pottery, glaſs, porcelain, &c. This branch of chemiſtry is highly cultivated and advanced in England, Germany, and Holland, and it is this branch which renders the moſt important ſervices to ſociety.

11. I ſhall diſtinguiſh the laſt department by the name of *Economical Chemiſtry*, becauſe its object is to elucidate, to ſimplify and regulate a number of economical proceſſes which are inceſſantly performed in our dwellings, in order to render them healthy, warm,

and light, and to prepare our food, beverage, and clothing. It ought to form a part of every judicious education, becauſe it is neceſſary for the preſervation of health. It is, in ſome degree, a familiar or domeſtic kind of chemiſtry. It is alſo very uſeful for deſtroying the prejudices to which the greateſt part of mankind are ſubject, and which are often more injurious to their welfare than the real evils to which they are expoſed.

ARTICLE III.

Hiſtorical Sketch of Chemiſtry.

1. WHEN the ſtudy of a ſcience is attempted, it would be ridiculous not to draw at leaſt the general outlines of its hiſtory: for, by exhibiting the principal changes through which it has paſſed, the dates of the diſcoveries are fixed, errors are expoſed, and the means of avoiding them are obtained; the repetition of trials already ſucceſsfully made is prevented; what remains to be done, is clearly pointed out, and the path to future diſcoveries is traced with perſpicuity and advantage.

2. In order to give to the preſent hiſtorical ſketch, which may ſerve as an introduction to the ſtudy of chemiſtry, the real utility it ought to poſſeſs, it is neceſſary to divide it into ſeveral principal epochas, which may ex-

hibit in the order of time, thoſe great revolutions which have at different periods changed the face of the ſcience.

3. I eſtabliſh ſix principal epochas in the hiſtory of chemiſtry: The firſt compriſes the ancient times; the ſecond its middle age; the third the origin of philoſophical chemiſtry, as well as the diſcoveries made after the eſtabliſhment of experimental philoſophy, and the foundation of learned ſocieties; the fourth relates to the diſcovery of the gaſes, and the great revolution which ſucceeded; the fifth to the foundation of the pneumatic doctrine; and the ſixth to the ſyſtematic nomenclature, and the conſolidation of that doctrine. There is this remarkable difference between the epochas, that the time which has paſſed is very unequally divided; that the firſt three occupy ſeveral ages, and compriſe the occurrences from the primitive nations to the middle of the eighteenth century,—while the three latter, compreſſed as it were together, and containing an immenſe courſe of labour, and an aſtoniſhing liſt of diſcoveries, preſent, in the ſpace of forty years, a greater degree of perfection and progreſs in human reaſon than is afforded by all the preceding and accumulated ages.

4. This is preciſely one of the particular, and, as it were, diſtinctive characters of chemiſtry. It has not proceeded with the regularity and connection which has accompanied every other ſpecies of human knowledge. It

has not experienced that ſlow and determinate progreſſion which has been obſerved in moſt of the other ſciences. Almoſt entirely unknown to the ancients, this ſcience only began to be conſidered as ſuch, towards the middle of the ſeventeenth century, and all the facts which had been collected during more than an hundred years, form almoſt an imperceptible point in natural philoſophy, when compared with the immenſe progreſs that has been made during the laſt thirty years.

5. Its hiſtory, treated in detail, and with all the attention it requires, will afford, particularly to poſterity, a moſt aſtoniſhing ſpectacle of the efforts of genius, and will occupy one of the moſt diſtinguiſhed places in the annals of human intelligence. The ſketch I am about to give would of itſelf be ſufficient to eſtabliſh this truth in the moſt ſtriking manner.

First Epocha.

The firſt Dawn of Chemiſtry in remote Ages.

6. THE firſt epocha of chemiſtry muſt, ſtill more than that of the other ſciences, be unavoidably involved in obſcurity and myſtery. Bergmann, who is the beſt and cleareſt writer on this part of chemical hiſtory, in his diſſertation, entitled "*De primordiis chimæ,*" begins by ſhowing to what the ſlow progreſs of natural

philoſophy ought to be attributed, by arguments founded on the difficulties of obſervation and experiments; the ſmall number of men whoſe attention is devoted to this ſubject; the ſcarcity of means and talents neceſſary to inſure ſucceſs; the prejudices to be overcome; the torpor of the human mind to be rouſed, and the deluſions of imagination to be repelled; and he obſerves that this earlieſt part of the hiſtory of chemiſtry is truly fabulous. He treats in this epocha under the five diviſions of the earlieſt chemical arts, of the traces of chemiſtry in Egypt and among the Greeks and different nations, and gives a general abſtract of the chemical knowledge in the firſt ages. Let us rapidly trace, with him, this obſcure path.

7. A ſcience can exiſt only by the compariſon of numerous facts and obſervations. Theſe facts, at firſt diſcovered by chance, and repeated by induſtry, to ſupply the wants of individuals, have conſtituted the arts. Their firſt inventors might, and indeed muſt, neceſſarily have been men of genius: they were deified, as a reward for their ſervices, while the great warriors were only conſidered as heroes. The firſt accounts relate to the founders of metals, operators at the forge, fabricators of arms and aratory inſtruments. Tubal Cain or Vulcan is mentioned, as having invented the art of coining money from gold and ſilver, in the time of Abraham; and to Noah is attributed the diſ-

covery of the fermentation of the grape, and the baking of bricks.

8. In Egypt the ſcience of the prieſts is thought to have been chemiſtry. It is aſſerted that after the time of Hermes, who inſcribed the elements of this ſcience upon columns, the prieſts tranſported them to the hieroglyphics of the temples and their ſubterraneous buildings. According to Diodorus, the Sicilian, the chemical arts were in a very advanced ſtate among the Egyptians. They prepared various medicines; they applied calcined aſhes as cauſtics; they had many compound articles of perfumery; they knew how to make plaſters with metallic oxides; they cut, engraved and poliſhed hard ſtones, particularly baſaltes; they fuſed and caſt the metals; they prepared bricks, extracted natron from the mud of the Nile, manufactured ſopes, alum, culinary ſalt and ſal-ammoniac; they extracted oil from olives and the ſeeds of radiſh; they preſerved bodies by embalming; they worked in gold and copper, and were acquainted with the proceſſes of metallurgy; they made glaſs, painted porcelain and enamels; they engraved upon glaſs, and knew the method of gilding and ſilvering; they prepared a kind of beer and true vinegar; and they dyed ſilk, by means of mordants. The whole of theſe arts, the exiſtence of which in ancient Egypt has been admitted by all travellers ſince the time of Diodorus, might well have perſuaded chemiſts that the

Egyptians poſſeſſed profound knowledge of the ſcience of chemiſtry.

9. We find fewer traces of chemiſtry among the Greeks, who nevertheleſs acquired their knowledge of the arts from Egypt. Their greateſt philoſophers, Pythagoras, Thales, Plato, &c. were more diſpoſed to cultivate the mathematics and aſtronomy, than the phyſical ſciences. At Corinth they manufactured famous alloys; ceruſe was made at Rhodes; cinnabar was uſed in Greece; they cut the hardeſt ſtones, and their ſculptors are far more celebrated than their chemiſts. Tychius tanned leather; Plato has given an accurate deſcription of filtration; Hippocrates was acquainted with the art of calcination; Galen ſpeaks of diſtillation *per deſcenſum;* and the ambic is mentioned by Dioſcorides, long before the particle *al* was added to that word. Athenæus mentioned a glaſs-manufactory that was eſtabliſhed at Leſbos. Democritus of Abdera prepared and examined the juices of plants. Ariſtotle and Theophraſtus treated of ſtones and metals. Many of the Grecians alſo devoted themſelves to the myſteries of alchemy. All the Greek philoſophers invented ſyſtems relative to the principles of bodies, their elementary principles, and their converſion. The arts were not more advanced than thoſe of the Egyptians; their philoſophy was ſyſtematic, and their chemiſtry had no ſcientific exiſtence.

10. The Iſraelites acquired their information in Egypt. It was there that Moſes learned the properties of metals, the method of extracting oils, the preparation of perfumes, the ſolution of gold, the dying of linen, vinification, acetification, gilding, and the fabrication of pottery, ſope, &c.

The Phenicians manufactured a quantity of glaſs, with which they traded: the celebrated Tyrian purple, with its three ſhades, was invented by this people. They alſo worked on the ores and metals. The Perſians gave the names of the planets to the metals.

In China, even in theſe remote ages, the inhabitants were acquainted with nitre, gunpowder, borax, alum, verdigris, mercurial ointments, ſulphur, colours, dyes for linen and ſilk, and with the art of making paper: they alſo manufactured porcelain and very numerous kinds of earthen ware; they made a number of metallic compounds. The uſe of wax and ivory was well known to them, and horn was very well manufactured. From this account of the ſtate of the arts, we may be permitted to conſider the Chineſe, according to Guignes, as an Egyptian colony.

The Romans made no addition to the chemical arts; they derived them from the Egyptians and the Greeks. We hear however that malleable glaſs was preſented to Cæſar, according to Petronius, or to Tiberius, according to Pliny. All that is related by the latter concerning the chemical arts, was known before the time of the Romans. A people always at war and victorious, had neither time nor inclination for cultivating the arts and bringing them to perfection.

11. If we were to fix the exiſtence of chemiſtry in the arts which it elucidated, it is evident that this ſcience would have preceded every other; that Egypt would have been its cradle; and that it has been cultivated for time immemorial in China; but no true ſcience in fact exiſted. Vinegar was the only acid then known; ſoda was denominated nitre; among the ſalts they treated only of ſea ſalt, ammoniac and alum; verdigris and the ſulphate of iron were the only known kinds of metallic ſalts. They diſtinguiſhed no other earth but lime and clay. Sulphur, the oils and bitumens were the only inflammable matters employed. They worked ſeven ductile metals; the brittle metals were unknown. There were but few real experiments made in chemiſtry; ſo that among the whole of theſe facts we perceive nothing more than the infancy of the art: there neither was nor could be any ſcientific ſyſtem.

SECOND EPOCHA.

The middle Age, or obſcure Times of Chemiſtry.

12. BERGMANN, who has written a very good diſſertation on this age, which will ſerve as a guide in the preſent article, dates its commencement at the ſeventh century, about the time of the deſtruction of the Alexandrian library by the Arabs, and makes it extend to the middle of the ſeventeenth century. This includes a period of about one thouſand years, during which the ſciences in general, and particularly chemiſtry, made but very little progreſs. It begins with the moſt ſhocking monument of Vandaliſm that has ever been recorded in the hiſtory of deſtructive war, the conflagration of the Alexandrian library, that focus of ſcience and information, which was followed by the deſtruction of every kind of knowledge. During theſe times, the barbarians, who over-ran and ravaged Europe, expelled the arts and ſciences wherever they appeared. After the cruſades they were again reſtored, and met with more repoſe and protection; but thoſe who cultivated them were obliged to combat the attacks of ſuperſtition and fanaticiſm, by which they were proſcribed as magicians and ſorcerers.

13. During all this epocha of war and deſolation, chemiſtry acquired only a few facts, without connection and without order. The ſcience itſelf became devoted to unreaſonable and extravagant purpoſes. It was directed to the making of gold and diſcovering of an univerſal remedy. Theſe two mental diſeaſes, the reſult of ignorance, devaſtation and ſuperſtition have long tormented the human race. The language of chemiſtry became myſterious, metaphorical, and notwithſtanding the anathemas of the church, and the vigilance of kings againſt the adept impoſtors and alchemiſts, who had increaſed beyond calculation, time alone could cure this leproſy of the mind, which exiſted during the whole period on which we treat. Such is the general ſketch of this obſcure epoch of chemiſtry as given by Bergmann. Among all the abſurdities which diſgrace it, one uſeful effect is to be met with; namely, that the alchemiſts, by their immenſe labours, have diſcovered a number of facts, which without their exertions, would have remained unknown.

14. One of the remarkable circumſtances of this period conſiſts in the application of chemiſtry to the materia medica by the Arabs. Theſe people were the firſt who uſed ſugar as an article of medicine, under the name of honey of canes. Rhazez made a great number of mixtures and compoſitions. He employed all the operations of chemiſtry in the preparation of medicaments. Albucaſis poſſeſſed ſtill greater

chemical knowledge than Rhazez; he very clearly deſcribed the three kinds of diſtillation, the apparatus for diſtilling, as well as a number of experiments. Geber, a chemiſt ſtill more deſerving of praiſe, was acquainted with corroſive ſublimate, aqua regia, and the ſolution of gold. Mezué purſued the ſame career, and deſcribed a number of pharmaceutic preparations; he was denominated the evangeliſt of the pharmacians.

15. Nicholas Prevoſt, a phyſician at Tours, collected and publiſhed at Lyons, in 1505, all the receipts and antidotes then known. Valerius Corduc, in 1542, publiſhed the firſt chemical pharmcopœia, in which he deſcribed ether with tolerable preciſion, under the name of ſweet oil of vitriol.

In the year 1270, Thaddæus, the Florentine, pointed out the medicinal property of alcohol. In the fifteenth and ſixteenth centuries, Baſil Valentin and Paracelſus employed many chemical preparations in medicine. The pupils of the latter ſtill farther extended the uſe of opium and mercury. Antimony, on account of the diſſentions and conteſts among the phyſicians, gradually became, by the efforts of the chemiſts, one of the moſt valuable remedies that exiſted in the whole materia medica. In 1609, Crollius publiſhed an account of the method of preparing ſweet mercury, or mercurius dulcis. The pharmacopœias were compoſed with great attention, perſpicuity, and methodical arrangement;

ment; that of Schroder, in particular, at the end of the epoch on which we treat, contained all the moſt important chemical preparations, with accurate deſcriptions of various proceſſes.

16. Economical chemiſtry and the chemical arts made but little progreſs during this period. The proceſſes of metallurgy remained involved in obſcurity till the eighth century; and it was not till the ſixteenth century that they were formed into a ſyſtem by G. Agricola. He was the firſt who publiſhed in 1546, a methodical work on metallurgy and the docimaſtic art, in twelve books, which compriſed all its parts. This was immediately ſucceeded by the treatiſes of Encelius, Faſch, and Lazarus Ercker. The glaſs employed for windows towards the cloſe of the third century was firſt manufactured in France, and afterwards in England, about the ſeventh century. Coloured glaſs and enamel were invented in Europe ſubſequent to the diſcovery of common glaſs.

17. Theſe general conſiderations on the ſlow progreſs of chemiſtry and the chemical arts in the middle age of ſcience, are given in the diſſertation of Bergmann in a vague manner, which does not afford any notion of the ſucceſſion of the leading men who cultivated the ſcience during that period. This defect muſt be ſupplied by a conciſe enumeration of the moſt celebrated chemiſts who have ſucceeded each other from the middle of the ſeventh to the

middle of the ſeventeeth century. After the Arabs already mentioned, who flouriſhed particularly in the eighth, ninth, tenth, and eleventh centuries, it is neceſſary to ſtate that alchemy became the predominant inſanity of the minds of men from the twelfth to the ſixteenth century, and that all the authors who wrote during this period, have more or leſs infected their works with this alchemical phrenzy.

18. The thirteenth century is remarkable for Albert the Great, a Dominican of Pologne, who was conſidered as a magician, doubtleſs on account of his chemical experiments; for Roger Bacon, born in the year 1214, near Ilcheſter in Somerſet, and celebrated for his inventions of the camera obſcura, the teleſcope, and gunpowder, for ſeveral ſingular machines, and for his great reputation which cauſed him to be called the admirable doctor; and laſtly, for the birth of Arnaud de Villeneuve, a native of Languedoc, who treated of the mineral acids, and, beſides his chemical erudition, poſſeſſed a vaſt knowledge of medicine.

19. In the fourteenth century we meet with Raymond Lulli, placed among the adepts, and who wrote upon the mineral acids and metals. He was ſucceeded by Baſil Valentin, a German Benedictine of the fifteenth century, famous for his treatiſe upon antimony, in which we find ſeveral preparations that have ſince been given to the world as new diſcoveries. Iſaacus Hol-

landus lived about the ſame time; his productions were much admired by Boerhaave.

20. The ſixteenth century was occupied by the ſchool of Paracelſus, who was born near Zurich in 1493; he was a famous chemiſt, and an enthuſiaſt of the ſcience and the remedies it afforded, deſpiſing all the ancient principles of medicine. He performed miraculous cures with opium and mercury, promiſed himſelf immortality by his remedies, and died in conſequence of his debaucheries, at the age of about forty-eight years, in a ſmall inn at Saltzburg. Many chemical phyſicians adopted and propagated the principles of Paracelſus, in the courſe of the ſixteenth and beginning of the ſeventeenth century. In this liſt, we find Crollius, Ortelius, Poterius, Beguin, Tachenius, Zwelfer, Glazer, Caſſius, Digby, Libavius, Angelus-Sala, Blaiſe de Vigenere, &c. Among theſe chemiſts, and nearly about the period when the works of ſeveral of them were publiſhed, it is neceſſary to diſtinguiſh Van Helmont, a man of genius, of whom I ſhall have farther occaſion to ſpeak; Becher, ſo famous for his treatiſe on the ſubterraneous world, and his extenſive views of ſcience; Kunckel, one of the firſt accurate writers on chemical phenomena; Glauber, illuſtrious for the great number of his diſcoveries, and for his advice and method of not rejecting as uſeleſs the reſiduum of experiments; and Kircher and Conringius, the wiſe and learned antagoniſts of alchemy.

21. Bergmann concludes his hiſtory of the middle age of chemiſtry, by a ſummary of the chemical diſcoveries made in the courſe of this period, or during the thouſand years it compriſes. The claſs of acids was increaſed by the diſcovery of the ſulphuric, nitric, and muriatic acids. The alkalis were rather better known, and the volatile alkali was extracted from ſal-ammoniac by Baſil Valentin, by means of fixed alkali. The ſulphate of potaſh, prepared in three or four ways, received different names; and that of vitriolated tartar, which it bore for a long time, was given it by Crollius. The nitrate of potaſh received the name of nitre, which till that time was applied to ſoda. J. Sylvius diſcovered the muriate of potaſh, which he called digeſtive ſalt, and Glauber, the ſulphate of ſoda, which he decorated with the name of admirable ſalt. Several earthy ſalts now began to be known, and among others the muriate of lime, under the name of fixed ſal-ammoniac.

The metallic ſalts alſo were inveſtigated; the nitrate of ſilver in the form and under the name of cryſtals of Diana, and the infernal ſtone, the muriate of ſilver, under the name of luna cornea; the two muriates of mercury were deſcribed and employed; the red precipitate, or coralline arcanum, the ſugar of lead, butter of antimony, powder of algaroth, antimonial tartar, the three vitriols, were either diſcovered or more carefully examined and diſtinguiſhed.

Sand was diſtinguiſhed from clay, lime water was prepared, and the alkaline ſulphurets were brought into notice.

The brittle metals, or ſemi-metals, were diſtinguiſhed from the ductile ſpecies; biſmuth, zinc, antimony, and even arſenic, were obtained in the metallic ſtate. A number of oxides, of protended metallic tinctures, particularly the purple mineral, fulminating gold, mineral turbith, the ſaline precipitates of mercury, or the mercurial oxides, of various colours, minium and litharge, colcothar, ſaffrons of Mars, diaphoretic antimony, &c. were diſcovered, and their preparations tolerably well deſcribed.

The diſtillation of volatile and empyreumatic oils was alſo begun; the ethers were diſcovered, ſpirit of wine was generally known, and even diſtinguiſhed by the name of alcohol, which it has retained to the preſent day.

22. After relating all theſe diſcoveries, as they are preſented by Bergmann in that period of the hiſtory of the ſciences on which we are now engaged, the reader will doubtleſs be aſtoniſhed, that our ſketch was commenced with the aſſertion that chemiſtry, like the other ſciences, has made but ſlow progreſs; and, in fact, this appears to be an evident contradiction to what has been ſaid in No. 12 of the preſent article, and what has likewiſe juſt been ſtated in No. 21. It is neceſſary, however, to remark, that moſt of theſe diſcoveries were made by the alchemiſts, beſides which, the greater number of them,

particularly thoſe which appear to us to deſerve the appellation of capital, belong only to the two laſt centuries of this long epocha; and that the torpor of the ſcience, as well as the obſcurity in which it was enveloped, belong entirely to the firſt eight centuries, from the middle of the ſeventh to the middle of the fifteenth. This epocha might therefore be divided into two others, if the laſt were not infected by the errors of alchemy. It ſhould alſo be added, that there exiſted no connection, no ſyſtematic method in chemical knowledge, which could form either a ſyſtematic aggregate or ſcience; and that all the incoherent facts of which we have juſt given an abſtract related more to the ridiculous ideas or exaggerations of alchemy, or the univerſal medicine, than to the advancement of a ſcience, which, in fact, did not really exiſt at that time.

THIRD PERIOD.

Origin of Philoſophical Chemiſtry; Labours of learned Societies; numerous Elementary Works.

23. THOUGH the character of the preceding epocha be drawn particularly from the want of every connected ſyſtem or methodical arrangement, nevertheleſs, the latter part of this period, particularly from the commencement of the ſeventeenth century, was marked by the publication of ſeveral works which contained the

firſt notion of a connection between the facts, and the mutual dependence of the truths already diſcovered. Such were thoſe of Libavius, Van-Helmont, Angelus Sala, Beguin, Brendelius, Rolfinck, Starkey, Viganus, and ſeveral others which appear to be applicable only to the time of their publication, during the period which has juſt been deſcribed, and to open, by the ſyſtematic attempts they began to exhibit, a path to that ſcience, which was formed ſoon after this period.

24. At the commencement, or as it were at the head of the period on which we at preſent treat, may be placed two men whoſe works have greatly excelled thoſe of their predeceſſors, on account of the clearneſs of the ideas contained in them, and the order and method of their arrangement: the authors were Barner and Bohnius. The publication of theſe two firſt philoſophical works on our ſcience coincides with the origin of experimental philoſophy, and muſt be conſidered as the birth of true chemiſtry. The philoſophical chemiſtry of Barner, and the treatiſe of rational chemiſtry by Bohnius have long been the only books of ſtudents. Stahl knew the firſt of theſe by heart at the age of fifteen years.

23. The minds of men being freed from the ancient yoke of opinions too highly credited, and at length corrected from the errors of alchemy, were led to new conceptions, by the diſcoveries and productions of Bacon, Deſ-

cartes, Leibnitz, Galileo, Torricelli, and the great Newton. They now began to perceive that it was by means of experiments that nature ought to be inveſtigated. Experimental philoſophy ſoon aroſe, and learned ſocieties began to be eſtabliſhed from about the middle to the end of the ſixteenth century. The academy *del Cimento,* founded at Florence, in 1651, the Royal Society of London, in 1660, and the Academy of Sciences of Paris, in 1666, were the nurſeries and defenders of experimental philoſophy and chemiſtry: in theſe ſocieties, the moſt important labours were undertaken, relative to the analyſis of a great number of bodies, &c. Among the immenſe reſearches compriſed in this period, of one hundred years, from 1650 to 1770, we muſt confine ourſelves to ſtate the moſt ſtriking facts and reſults with the names of the moſt celebrated chemiſts who have produced them, together with the moſt important advances they have made in the ſcience itſelf.

26. The analyſis of waters was begun at Paris by Duclos: the diſtillation of plants by naked fire was performed with great attention by Dodart and Boulduc. Leibnitz examined the phoſphori and the waters of Berlin, and founded the Academy of Pruſſia in the year 1700, upon the plan of that at Paris. Newton himſelf began to communicate to the Royal Society of London, ſome new and general ideas on chemical phenomena. Boyle combined a

number of chemical obſervations with philoſophical experiments. At Paris, the two Lemerys, the three Geoffroys, Lefebvre, Glazer, Homberg, Hellot, and Duhamel enlarged the ſphere of the ſcience, while in Germany, Pruſſia, and Sweden, it was cultivated and advanced by Henckel, Schlutter, and others; in England by Starkey, Morley, Wilſon, and Slare; and in Holland by Glauber, Sylvius, and Le Mort.

27. Among theſe indefatigable philoſophers, one man aroſe in Pruſſia, who fixed the theory of the ſcience for half a century by the moſt impreſſive arrangement, and the moſt extenſive and connected ſyſtem. The illuſtrious Stahl, enlightened by the labours and views of Kunckel, and particularly of Becher, on whoſe works he commented, was the inventor of an ingenious ſyſtem upon combined fire, which he applied to all the facts then known, and which, under the name of phlogiſton, before denominated inflammable earth by Becher, produced for the firſt time, a parent idea, embracing the whole ſcience, by the re-union of all its parts; and deſerving to unite the ſuffrage of all men poſſeſſed of the ſpirit of philoſophy. Boerhaave, on his part, at Leyden, contributed much to the formation of philoſophical chemiſtry, which he enriched with a number of experiments on fire, heat, light, the vegetable analyſis, &c. In the ſteps of theſe celebrated men, with the ſame ſpirit, and by purſuing the path which they had opened, the moſt able

chemiſts have proceeded for more than fifty years. Among theſe enlightened individuals, diſciples and promoters of the Stahlian ſchool, particularly thoſe of France, we muſt rank the names of Groſſe, Baron, Macquer, the two Rouelles; in Germany and Sweden, Pott, Cronſtedt, Wallerius, Lehman, Gellert, Margraaf and Neumann; in England, Freind, Shawe, Lewis; in Holland, Gaubius, &c. &c.

28. Geoffroy the elder, a phyſician at Paris, Member of the Academy of Sciences, and author of the celebrated Materia Medica, ſhines in the midſt of this celebrated liſt, for the happy thought of repreſenting the chemical affinities, in a table which he publiſhed in 1718.

In a table of ſixteen columns, containing the principal bodies at that time known, which he diſpoſed according to the order of their mutual affinity, he preſents the ingenious method of deſcribing, in a very limited ſpace, the reſults of the principal experiments in chemiſtry. This real and moſt important diſcovery has directed a great number of chemiſts, who have added many articles to his work, but who are evidently indebted for the idea to the illuſtrious Geoffroy. Thus the tables of affinity by Rouelle, Limbourg, Machy, Wenzel, and even thoſe of Bergmann, which have ſurpaſſed all the others, are certainly nothing more than the invention of Geoffroy enlarged and continued.

29. During the ſpace of one hundred years, ſo remarkable in the annals of ſcience, for the

deſtruction of ancient errors, for the origin of experimental philoſophy, and the eſtabliſhment of learned ſocieties; and no leſs remarkable for its great number of practical chemiſts, the maſs of new facts and diſcoveries muſt neceſſarily have been conſiderable. It will be ſufficient, in this place, to give a ſlight enumeration, in order to afford an adequate notion of their magnitude. The diamond was found to be combuſtible; the inflammable and mephitic gaſes of mines were diſtinguiſhed; Lemery made his artificial volcano with moiſtened ſulphur and iron; the mineraliſation and heat of waters were accounted for; phoſphorus was diſcovered, and the method of extracting it from human urine carefully deſcribed in 1737. Kunckel and Henckel conſiderably advanced the chemical hiſtory of metals; cobalt, arſenic, zinc and their ores became better known; the examination of the chemical properties of iron, antimony and mercury, gave riſe to a number of new preparations; the ſimilarity and difference between theſe preparations, and their ſyſtematic claſſification, were more exactly determined; platina was diſtinguiſhed from the other metals, and its principal characters diſcovered; nickel and mangameſe were added to the order of metals. Docimaſy and metallurgy were highly improved, and the works of Cramer, Schlutter, Schindler, Delius, Juſti, Wallerius, Tillet, Hellot and Jars, tended to correct a number of errors, by elucidating the proceſſes, and connecting them with the ſcience. All the pharmaceutical preparations were greatly corrected and improved; and the errors introduced by chemiſtry into the curative art became infinitely leſs dangerous.

30. During this period the analyſis of vegetables in particular experienced very happy amendments. After the labour of thirty years on the diſtillation of plants by naked fire, it was diſcovered that a falſe proceſs had been adopted; and the examination of vegetables by ſolvents was then began; the fermentations were ſtudied and claſſed; the immediate materials of plants were carefully purified and diſtinguiſhed from each other; the properties of each were ſtudied and determined; ſeveral even of theſe materials, ſuch as gluten, caoutchouc, the eſſential ſalts, and colouring ſubſtances were diſcovered; etherification became one of the moſt conſtant and remarkable phenomena of the analyſis of alcohol; the arts which have vegetables for their object, particularly baking, dyeing, ſope-boiling, &c. received very great improvements.

31. The animal analyſis derived advantages from the birth of philoſophical chemiſtry, from the ſcientific ſocieties, and from the ſucceſsful labours of thoſe chemiſts who flouriſhed in the third period of the hiſtory of the ſcience, equally great with thoſe of the chemiſtry of minerals and vegetables. Schloſſer and Margraaf made the valuable diſcovery of phoſphoric ſalts in urine, and of the true origin of the phoſ-

phorus extracted from this animal fluid. Rouelle, the younger, and Poulletier de la Salle examined the animal fluids and ſome of the ſolids. The property of animal ſubſtances of producing volatile alkali by heat and putrefaction was proved, which Van Helmont, upwards of a century before, had indicated as one of the diſtinctive characters of theſe bodies: the cauſes and phenomena of putrefaction were alſo ſtudied with conſiderable attention. But, in the courſe and number of theſe labours, it muſt be admitted that, notwithſtanding the connection already eſtabliſhed between them, they have left the ſcience in that vague and indeterminate ſtate which is likewiſe obſervable even in the vegetable analyſis, and which forms the diſtinctive character of the period on which we treat with reſpect to organic ſubſtances.

32. The reſult of the hiſtory of this third period conſiſts in the real formation of the ſcience, the ſyſtematic order and connection eſtabliſhed between all the known facts, the condenſation of all the diſcoveries made during this period, and their methodical diſpoſition into a ſyſtem of chemical knowledge. Moſt of the important treatiſes, in which chemical facts have been combined and publiſhed, with a ſcientific method that it would be in vain to expect before this period, were written after the time of Stahl and Boerhaave, after the firſt thirty years of the eighteenth century.

33. Among the claſs of celebrated chemiſts of whom I am here to ſpeak, and whoſe philoſophical works have glorioufly terminated the forty years of the period under conſideration, may be particularly mentioned, 1. Senac, author of Nouveau Cours de Chimie, ſuivant les principes de Newton et de Stahl," publiſhed in 1723: 2. Juncker, author of the "Conſpectus Chimiæ theorico praticæ," publiſhed at Halle, in 1730, 1738, 1744 and 1750; 3. Shaw, author of the "Chemical Lectures at London, in 1733; 4. Cartheuſer, author of the "Elementa Chemiæ dogmatico-experimentalis," 1736; 5. Macquer, author of "Elemens de Chimie theoretique," in 1749, and of "Elemens de Chimie pratique," in 1751; 6. Vogel, author of "Inſtitutiones Chimiæ," Gott. 1755; 7. Fred. Hoffman, author of "Chemia rationalis et experimentalis," 1756; 8. Spielman, author of "Inſtitutiones Chemiæ," 1763.

FOURTH PERIOD.

Diſcovery of the Gaſes; Commencement of a great Chemical Revolution.

34. NOTWITHSTANDING the exertions of the operative chemiſts of the preceding period, an immenſe chaſm ſtill exiſted in the ſcience. Too little attention had been paid to the influence of the air; from which the minds of men

were diverted by the ſubject of combined fire, as explained by Stahl. Elaſtic fluids were diſengaged in many operations which were indiſtinctly ſuppoſed to be air, and theſe which often formed the greateſt part of the products, were neglected. There was alſo an abſorption of air in many other operations, and no one had endeavoured to appreciate its influence. It was upon the knowledge of theſe two phenomena that a revolution was advancing, of which the influence was deſtined to produce a total change in the whole ſcience of chemiſtry.

35. Van Helmont ſaw and myſteriouſly announced the gaſes in 1620.

J. Rey apprehended the fixity of air in calcined metals in the year 1630.

Boyle made many new experiments upon air at the end of the ſeventeenth century, but as they were rather phyſical than chemical, his experiments did not ſufficiently alter the views and manipulations of the chemiſts.

Mayow made experiments to aſcertain the influence of air in combuſtion and reſpiration, in 1669; he drew aſide the veil by his ingenious reſearches; but they were almoſt unintelligible to his cotemporaries, and his aſſertions were claſſed among hypotheſes and ſingular opinions, and the veil again fell.

In 1723, Hales made a number of experiments on elaſtic fluids diſengaged in diſtillation, &c. but, always conceiving that he obtained air more or leſs changed, and even endeavouring

ing to purify it, he derived from all his labour only an erroneous reſult, viz. that air was the cement of bodies, and the cauſe of their ſolidity. There was no connection whatever between theſe firſt attempts; the connection that has ſince been diſcovered between them was totally deſtroyed after the time of Hales. The facts already diſcovered ſeem to have been ſoon forgotten, as well as the original notions to which they had given riſe.

36. In 1750, Venel, profeſſor of Chemiſtry at Montpellier, reſumed the courſe of his experiments, by condenſing in water the fluid diſengaged by effervеſcences, and by its artificial ſolution he imitated the acidulous mineral waters; but he ſtill exerted all his efforts to prove that this elaſtic fluid was air.

In 1755, Black, profeſſor of Chemiſtry at Edinburgh, examined the pretended air of effervеſcence; and proved that it is not air, that it is readily abſorbed by cauſtic alkalis, that it renders them mild, and effervеſcent, that it is diſengaged from them by lime, which it converts into chalk; but he continued to uſe the name of fixed air, which Hales had given it thirty years before, without, however, diſtinguiſhing it from air, as Black now did. The remarkable facts obſerved by the latter reſpecting the difference between this fluid and air, with which it had till then been confounded, made a great impreſſion upon the minds of chemiſts; and induced them to examine its properties with attention. Such was the origin of an immenſe revolution, which, by enlarging its dominion, has totally changed the whole aſpect of the ſcience.

37. At the ſame time that Black made this capital diſcovery at Edinburgh, Saluces, at Turin, examined the gas diſengaged from gunpowder, during its inflammation. He compared it to that of efferveſcence. In both he diſcovered the property ſo different, namely, of extinguiſhing bodies in combuſtion; he diſtinguiſhed it by ſeveral other of its characters; but he was leſs accurate than Black in his concluſions, and ſtill conceived it to be air, altered by foreign matters.

38. Immediately after Black, Brownrigg, in England, found that Pyrmont water contained, as the principle of its gaſeous and acidulous property, the ſame elaſtic fluid that Black had diſcovered in the efferveſcent alkalis, in chalk and magneſia; and thus he combined, by one of the moſt happy coincidences, the experiments of Venel, on briſk acidulous waters, then called ſpirituous waters, with the diſcovery of the celebrated profeſſor at Edinburgh.

39. But during the time while Macbride, in 1764, repeated and added to the experiments of Black, upon fixed air, while he extended his views reſpecting the properties of this new fluid, and made an ingenious application of it to the animal economy and medicine, a ſkilful German chemiſt, Meyer, of Oſnabruck, advanced

an opinion on lime and alkalis quite oppoſite to that of Black. He admitted in theſe cauſtic ſubſtances, a principle of an ingenious creation, of which he did not indeed prove the exiſtence, but he maintained his hypotheſis by experiments calculated to impoſe on many ordinary thinkers. This principle he denominated *cauſticum*, or *acidum pingue;* he ſuppoſed the tranſition of heat in lime, alkalis and metals, and thus explained the phenomena of all calcinations.

40. This new dectrine ſoon divided the chemiſts into two claſſes; thoſe who believed in the cauſticum of Meyer, and others who admitted the fixed air of Black. Nearly the whole of Germany appeared diſpoſed to adopt the ſyſtem of the *acidum pingue*, though it was only an imaginary principle, while fixed air was a real one; when, in 1769, Jacquin, profeſſor of chemiſtry at Vienna, in Auſtria, publiſhed a learned diſſertation, abounding with facts, equally curious and accurate, in which he examined and compared both doctrines. He evidently proved that fixed air explained, by rigorous experiments, the cauſticity of the alkalis, of lime, and the action of the latter upon the former; and that it is collected by the action of heat during the calcination of chalk. The order of this learned diſſertation, the clearneſs of the ideas of its celebrated author, the force of his reaſoning, and the nature of the facts themſelves which he quoted, threw ſo great a light

a light upon the queſtion which was to decide the fate of chemiſtry, that the greateſt number of chemiſts adopted and admitted the exiſtence of fixed air, as a body very different from common air. Even the arguments employed by Crans, in oppoſition to thoſe of Jacquin, in a diſſertation which he publiſhed in 1770, to defend the theory of Meyer againſt that of Black, tended rather in the opinion of men of perſpicuous reaſoning to prove the exiſtence and properties of fixed air, than to invalidate the arguments of his opponent.

41. Cavendiſh, a philoſopher at London, publiſhed, in 1766 and 1767, in the Philoſophical Tranſactions, a courſe of important experiments, which greatly advanced the knowledge and general theory of elaſtic fluids. By examining fixed air with apparatus ſtill more exact than thoſe of Black, he determined the principal differences between it and air, found it to be heavier than that fluid; inſiſted on its abſorption by water and the alkalis, proved that after having precipitated water from lime, in the form of chalk, it then rendered the chalk ſoluble, indicated the nature of its acid, ſhowed that charcoal on being burned produces fixed air, and thus he became the moſt ardent propagator of the doctrines of Black. He likewiſe diſcovered two other ſpecies of elaſtic fluids; namely, the muriatic acid gas, and inflammable air, of which he determined ſeveral of the properties. This immenſe advancement proved

the exiſtence of a number of bodies, all more or leſs different from air; were capable of aſſuming and preſerving the aërial form, and conſequently that, in the experiments made previous to that period, many products had been ſuffered to eſcape under that form, or under the name of air, of which the examination of the properties and the calculation of the effects in analyſes and combinations were undoubtedly of much importance.

42. The courſe was thus at length opened, to which all chemiſts were invited for the purpoſe of inveſtigating theſe new aëriform products, of examining their differences, their nature, and their action upon different ſubſtances, and the action of various bodies upon them. The diſcoveries relative to theſe fluids ſoon increaſed without intermiſſion, and chemiſtry was daily enriched by new facts of greater or leſs importance, on the nature, difference and properties of theſe gaſeous bodies. Lane, an Engliſh chemiſt, diſcovered, in 1769, that iron was ſoluble in water impregnated with fixed air: Smith, again comparing, in 1772, the new properties of fixed air, with thoſe of common air, inſiſted on the differences which diſtinguiſhed them, and attempted to claſs, though ſtill very imperfectly, the different kinds of elaſtic fluids, which he denominated gaſes, without however yet refuſing to believe them to be air ſuperſaturated with various foreign ſubſtances: ſo much had this firſt idea, conſigned in the inquiries of

Hales, tended to retard the progreſs of diſcovery in the intimate knowledge of the true nature of theſe fluids.

43. Dr. Prieſtley, who had been for ſome time engaged in immenſe ſeries of experiments and inveſtigations concerning the gaſes, which he improperly defined by the name of different ſpecies of air, ſuddenly enlarged this courſe, by increaſing our knowledge of the gaſeous bodies, by inventing more ſimple apparatus than had before been uſed for the mere purpoſe of collecting, preſerving, and transferring them from one jar to another, and bringing them into contact with other bodies. Woulfe, another Engliſh chemiſt, had greatly improved the operations of chemiſtry, by adding to the receivers which were formerly perforated, in order that the ſubſtance ſuppoſed to be air might eſcape, tubes which communicated with bottles full of water, in which ſaline gas or vapours were received and condenſed. Prieſtley, one of the moſt illuſtrious philoſophers who ever contributed to the ſtock of pneumatic diſcovery, and who alone diſcovered a greater number of elaſtic fluids than were known before or ſince his time, publiſhed in 1772, his firſt work upon the different kinds of air. He there examined in ten ſections, the fixed air extricated from beer in a ſtate of fermentation, with which he acidulated water in the ſame manner as with that procured from the effervеſcence of alkalis; the air which has ſerved for the combuſtion of candles, and for

reſpiration;

reſpiration; that in which a mixture of ſulphur and iron had been expoſed; that which had ſerved for the combuſtion of charcoal and the calcination of metals; inflammable air, marine air, and nitrous air. The mere expoſition of theſe titles prove that Prieſtley had the double intention of determining the change produced in air by combuſtible bodies, and all the proceſſes then called phlogiſticating, becauſe it was believed that phlogiſton was diſengaged, and combined with air, and alſo of determining what were the different ſpecies of aëriform fluids obtained in the numerous experiments, in which a diſengagement of theſe fluids is afforded. Prieſtley more particularly collected the proofs that theſe gaſes were very different from air, and that it is neceſſary carefully to diſtinguiſh them; and though he continued to deſcribe them by the name of ſpecies of air, on account of their form, he alſo remarked that it was not neceſſary to conſider them as ſolutions of various materials in the air of the atmoſphere.

44. Rouelle the younger, had the ſame notion of theſe fluids, when, in 1773, he publiſhed in the Journal of Medicine, a diſſertation upon fixed air, on its ſolution in water, its combination with iron, on the air diſengaged from liver of ſulphur, which was afterwards denominated by Bergmann hepatic gas, and which the French chemiſt here ſpoken of, firſt conſidered as the mineraliſer of ſulphureous

waters, ſo long ſought after, and which till that time, had greatly embarraſſed the reſearches of chemiſts.

45. The ſame year, 1773, was remarkable on the one hand, for the falſe notion which ſome chemiſts ſtill wiſhed to maintain, namely, that the different kinds of fixed air ought only to be conſidered as if air had undergone ſome alteration; for this claſs of chemiſts confounded under the name of fixed air, the various kinds of elaſtic fluids, which, according to their doctrine, were to be conſidered merely as air impregnated with different foreign ſubſtances, though they exhibited no exact or poſitive proof of this aſſertion;—and, on the other, by the honourable prize which the Royal Society of London publicly adjudged to Prieſtley, for having carefully examined the various kinds of gas, which he ſcrupulouſly diſtinguiſhed from common air, and on which he had publiſhed his firſt experiments, and communicated to the ſociety the new reſults which he propoſed to follow and improve. The illuſtrious Preſident of this Society, Pringle, in a very intereſting diſcourſe upon the occaſion of the prize adjudged to Prieſtley, repeated all the diſcoveries that had previouſly been made upon theſe new fluids, and gave an outline of the advances which the ſciences were entitled to expect from ſuch ſucceſsful beginnings.

46. Bergmann removed every doubt with regard to the nature of fixed air being different

ent from that of common air, in a learned diſſertation publiſhed in 1773. He proved that this fixed air is a real acid, and he diſtinguiſhed it by the name of aërial acid. Citizen Guyton, alſo remarked in 1774, that a few drops of ſulphuric acid in a great quantity of water, produced an imitation of water acidulated by the aërial acid.

Bewley, in 1775, adopted the doctrine of its particular nature, and deſcribed it by the name of mephitic acid.

In the ſame year Chaulnes examined at Paris the air diſengaged in the vats of breweries. He made ſome ingenious experiments on this fluid before the Academy of Sciences; he alſo diſcovered the means of preparing acidulated water with facility, by agitating water over vats containing beer in a ſtate of fermentation.

47. Bayen, in 1774, publiſhed his valuable experiments on the reduction of metallic calces without addition; he obſerved that a portion of air is diſengaged; and that phlogiſton was not always neceſſary to effect their reduction; he began to ſhow the little neceſſity and even the errors of the theory of Stahl. The ſame year, in the month of Auguſt, Prieſtley made the important diſcovery of vital air, which he denominated dephlogiſticated air; he alſo began to throw conſiderable light on the proceſſes of eudiometry.

48. At this time chemical diſcoveries and new ideas increaſed to ſuch a degree that it

would be neceſſary to follow them from month to month, in order to give an adequate degree of information concerning them. Berthollet, in 1776, publiſhed obſervations upon air, in which he ſhowed that the tartareous acid is changed into fixed air by heat, that the acetous acid gives out much inflammable and fixed air during its decompoſition; that vital air is contained in the acid of nitre, as well as in metallic calx. Bayen proved that the aërial acid is the mineraliſer of ſpathoſe iron ores.

49. During this period, Scheele, guided by the genius of chemiſtry, made his numerous and brilliant diſcoveries in Sweden. Bergmann had diſcovered that ſugar is converted into an acid by means of the nitric acid; and Scheele proved that this acid is the ſame as that which exiſted in ſorrel. He taught us to diſtinguiſh various vegetable acids, particularly the citric, the malic, and the gallic; he diſcovered the metallic acids of arſenic, tungſten, and molybdena; he threw the greateſt light upon manganeſe; he diſcovered the dephlogiſticated marine acid; and he ſaw partly the nature of the volatile alkali and the pruſſic acid; and after having made a long ſeries of experiments upon air, heat, and light, he, at length, attempted to eſtabliſh a general theory of chemiſtry, very different from that of Stahl, which Bergmann adopted, illuſtrated it by his manner of philoſophizing, and enlarged it by a number of elucidations; but this theory in-

cluded ideas and ſuppoſitions ſo numerous and ſingular, that it was followed and adopted only by a ſmall number of German chemiſts.

50. In England, Prieſtley continued his numerous inveſtigations relative to the gaſes, which he ſtill denominated kinds of air; he diſcovered the ſparry acid air, and the ſulphureous acid air. The number and oppoſition of his experiments however, embarraſſed his theoretical progreſs to ſuch a degree, that he was inceſſantly confounded in his explanations. Macquer, at this time, perceiving the neceſſity of changing the general theory of the ſcience, was induced to ſubſtitute light inſtead of phlogiſton, to conſider it as precipitating air, and thus to combine the new with former diſcoveries and with the doctrine of Stahl. In the mean time, Bayen, Prieſtley, Fontana, Berthollet, Scheele, and Bergmann, continued their labours and their diſcoveries. Volta deſcribed his ingenious experiments upon the inflammable air of marſhes, on its detonation with vital and atmoſpheric air, on the manner of determining the quantity of vital air in the atmoſphere by this detonation. Prieſtley diſcovered in vegetables the property of ameliorating corrupted air as he thought it, or of actually giving out vital air to the atmoſphere. The mephitic or aërial acid was diſcovered in many ſubſtances. Fontana diſcovered it in the malachite, and Laborie in the white ſpathoſe lead ore.

51. A crowd of diſcoveries, new facts, and curious experiments ſucceeded with aſtoniſhing rapidity. The academical memoirs, the periodical works and particular diſſertations were ſcarcely capable of publiſhing all the new facts that were diſcovered. The ſcience engaged general attention; and yet while it became enriched with innumerable facts, its theory proceeded but ſlowly: it even appeared to loſe ground, and to be embarraſſed amidſt theſe immenſe acquiſitions. Every chemiſt had his particular theory; and no complete ſyſtem was to be found, no certain connection between theſe reſults of which the multiplicity actually overwhelmed the ſcience. A man of an extenſive mind was wanting, who might profit by this ſtate of uncertainty and indeciſion, to arreſt and fix the progreſs of chemiſtry. A revolution was prepared in every quarter, but no one had yet undertaken to guide it, or to direct and regulate its motion. A great change in the theory was neceſſary, and it was in the boſom of the Academy of Sciences at Paris, that it was effected under the auſpices, and by the genius of Lavoiſier. Such was the ſource and origin of the French pneumatic doctrine, which forms the fifth period that I ſhall diſtinguiſh in this hiſtorical ſketch.

FIFTH PERIOD.

Foundation of the Pneumatic Doctrine.

52. THOUGH we are indebted to Lavoiſier, for a ſeries of important chemical diſcoveries, which would be ſufficient to place him among the firſt philoſophers of his age, yet it is much rather by the immenſe improvements which he introduced into the experiments of chemiſtry; by the exactneſs of the reſults he deduced from them; by the power of his genius, which exhibited and laid open a new courſe; by the extreme and ſevere preciſion of his reaſoning, and in ſhort, by the creation of a new doctrine, founded upon all the facts relative to elaſtic fluids, that the annals of the ſcience will conſecrate his name to poſterity. No leſs illuſtrious than Stahl, for the generality of his notions, and the profundity of his views, more fortunate than him by the nature of the labours of his age, which approached more nearly to the truth, he was the chief of that ſchool which by deſtroying all the errors of thoſe that had preceded it, was deſtined to raiſe an unperiſhable monument to nature by the eſtabliſhment of the French pneumatic doctrine.

53. Known and eſteemed by philoſophers ſince the year 1768, for a number of extenſive and extremely accurate philoſophical experiments,

ments, he ardently embraced the new diſcoveries made in England and Germany upon fixed air and the elaſtic fluids; he repeated all the experiments of Black and others in 1771 and 1772, and publiſhed at the beginning of 1774 his firſt work intitled: "Nouvelles recherches, &c. New inquiries relative to the exiſtence of an elaſtic fluid in ſeveral ſubſtances, and obſervations on the phenomena which reſult from its diſengagement or its fixation." In this firſt work, which was, as it were, only a trial of his powers, and a ſketch of the immenſe labours he had projected and even then commenced, he ſhowed how great a degree of preciſion might be attained in chemical experiments: by purſuing the fixed air of Black in its fixation, its diſengagement, its tranſition from one body to another, he aſcertained the quantity diſengaged or fixed; he proved that it is diſengaged during the reduction of metallic calces with charcoal, he announced that a portion of air is fixed in metals during their calcination, by which their weight is augmented; he ſuſpected that charcoal entered into the compoſition of fixed air, the denomination of which he rejected in order to employ the ſimple terms elaſtic fluid: he examined the properties of water impregnated with this fluid; he proved that phoſphorus in burning, and becoming an acid, abſorbs one fifth of the bulk of the atmoſphere, or twice its own weight of a ſubſtance exiſting in the air; that water does not contribute to this phenomenon; that the air which was abſorbed appeared to be ſpecifically heavier than the air itſelf. This work was, in fact, only a ſummary of all the ideas and new facts which he intended to publiſh at a future period.

54. Scarcely had Lavoiſier publiſhed this firſt production, when, aware of the extenſive engagement he was under with the learned world, he prepared all the materials that were neceſſary to enable him to purſue his new career, and to accompliſh the great objects which he had in view: accurate implements, numerous laboratories, learned communications, all were united in the place of his reſidence, for the completion of his views.

In 1772, he gave a memoir upon the combuſtion of the diamond, in which he made it appear that there is a remarkable ſimilarity between the combuſtion of this body and that of charcoal, a reſemblance which has been ſtrongly confirmed ſince that period.

In 1774, he deſcribed the calcination of tin in cloſe veſſels, the increaſe of its weight correſponding to the loſs of weight of the air in the veſſels in which he made the experiments: he ſtated that this operation conſtitutes an analyſis of air, by abſorbing the reſpirable part, and leaving the non-reſpirable part, which he denominated atmoſpheric mephitis.

In 1775, he explained the nature of the aërial principle ſuſceptible of combining with metals, and increaſing their weight during calcination;

cination; he repreſented it as the moſt reſpirable, part and proved that by heating precipitate *per ſe* with charcoal, which firſt when heated alone, afforded the only reſpirable air, he obtained fixed air, which was not contained in the precipitate, and in the formation of which the charcoal aſſiſted.

In 1776, his attention was directed to the exiſtence of air in the nitrous acid, as well as to the decompoſition and recompoſition of that acid. After having obſerved that phoſphorus and ſulphur abſorb one-fifth of their bulk of air, on burning, that by this abſorption they become acids, he aſſerted that the ſame effect takes place with reſpect to the acid of nitre; that it contains air like the preceding; that the acids differ from each other only by the baſe which is combined with air; that acidity might be taken from or given to them, by the privation or addition of air; that the metals by being diſſolved in the acids, deprived them of this air, and cauſed a diſengagement of different elaſtic fluids; that mercury might thus be employed in the analyſis of acids. He particularly acquainted the academy with the analyſis of the nitrous acid by this new method; with the difference between the two acids of nitre, according to the reſpective proportion of the two principles, reſpirable air and nitrous air, of which he ſhowed the compoſition. He ſhowed that phlogiſton is of no uſe in this explanation,

planation, and might therefore be diſpenſed with.

55. The year 1777 was the real period of the glory of Lavoiſier, by the creation of the pneumatic doctrine; by the numerous diſſertations which he publiſhed; by the new facts, the reſults of which he connected; by the attacks which he made on the theory of phlogiſton; by the force and the multiplicity of proofs which he accumulated for the propagation of his new doctrines, all founded upon accurate experiments. It was in the courſe of this memorable year, to which he himſelf, in his ſubſequent production, referred as the time of the origin of the pneumatic doctrine, that he ſucceſſively preſented the eight following memoirs.

a. On the phenomena and reſults of the combuſtion of phoſphorus; he here proved that atmoſpheric is compoſed of one-fourth of pure air and three-fourths of mephitis.

b. On reſpiration. He compared this function to the combuſtion of mercury, ſhowed that air corrupted by reſpiration extinguiſhes a candle, renders lime-water turbid, is loaded with fixed air, which he denominated, with Bucquet, cretaceous acid; and that there is a deſtruction of vital air; a ſeparation and inſulation of atmoſpheric mephitis, and a formation of cretaceous acid, as in combuſtion.

c. A memoir on the combuſtion of candles in common air, and air eminently reſpirable; he ſhowed that the air was not perceptibly diminiſhed in bulk; that one tenth was changed into cretaceous acid; that phoſphorus afterwards deprived it of additional reſpirable air, though there was left a portion of 0,05, which pyrophorus alone could abſorb.

d. A memoir of the ſolution on mercury in the vitriolic acid, and the decompoſition of the latter into ſulphureous acid gas, and into air eminently reſpirable. He proved particularly that the ſulphureous acid is vitriolic acid, deprived of part of its air.

e. A memoir on the combination of alum with carbonaceous ſubſtances, and on the formation of pyrophorus. He ſhowed how atmoſpheric air was affected by this combuſtible body, which changes all its pure air into cretaceous acid.

f. On the vitrioliſation of pyrites; he proved that this phenomenon ariſes from the abſorption of reſpirable air. It was in this memoir that he began to attribute flame and heat to the matter of fire diſengaged from reſpirable air, in proportion as it became fixed in combuſtible bodies.

g. A memoir on the combination of the matter of heat with evaporable fluids, and on the formation of elaſtic fluids: he began to generaliſe his ideas reſpecting the nature of heat, its two ſtates, evaporation, the cooling which accompanies it, the heat which, on the contrary, follows the fixation of elaſtic fluids, and to define the gaſes as ſolutions of volatile bodies in the matter of heat:—ideas which, though formerly taught by Black, were ſtill but little known in France, and tended to facilitate the introduction of all the other data of Lavoiſier.

h. A memoir on combuſtion in general. After having obſerved that the theories in natural philoſophy are nothing elſe but methods of approximation, he preſented with much order and clearneſs, the phenomena of all combuſtible bodies, he reduced them to four genera, inſiſted upon acidification being their moſt conſtant produce, and upon the poſſibility of accounting for them all by the mere fixation of the baſe of pure air, without having recourſe to the phlogiſton of Stahl, or to the diſengagement of light, which had juſt been ſubſtituted by Macquer, though, without deſtroying all the objections and all the difficulties, which neceſſarily followed the admiſſion of this hypothetical principle.

56. In 1778, Lavoiſier publiſhed General conſiderations on the nature of acids, and the principles of which he conceived them to be compoſed. In this treatiſe, for the firſt time, he denominated the baſe of pure air, the oxidifying principle, or oxigen, and proved that it is contained in all the acids. He applied this theory to the formation of acid of ſugar, the diſcovery of which, due to Bergmann two years before, began to make ſome noiſe in France. He announced that this new principle of the acids might be employed in the analyſis

of animal and vegetable ſubſtances; that charcoal appeared to exiſt ready formed in vegetables, and that innumerable applications relative to the action of oxigen in moſt chemical operations and phenomena, might be ſucceſſively made.

57. In 1780 he publiſhed three memoirs which threw a new light upon the doctrine, for the eſtabliſhment of which he laboured with extreme ardor for three years: by firſt applying to the examination of ſuch fluids as could be obtained in the aëriform ſtate, at a degree of heat little greater than the mean temperature of the earth. He proved that our terreſtrial atmoſphere is formed of bodies which, at the known temperature and preſſure are capable of preſerving the aëriform ſtate; that if the earth were nearer to the ſun, alcohol, ether, and even water, would form a part of the atmoſphere; and that, on the contrary, if it were at a greater diſtance from that luminary, water and mercury would be ſolid; that the three ſtates of ſolidity, liquidity, and gaſeity, depend on the different proportions of fire combined in bodies; and that the elaſtic fluids being arranged according to their ſpecific gravity, it is evident that the upper regions of the atmoſphere muſt be occupied by inflammable gaſes, and are therefore the place of luminous and combuſtible meteors.

In the ſame year, 1780, he ſhewed the method of converting phoſphorus into phoſphoric acid, by means of the acid of nitre, and proved that this converſion is effected, in conſequence of the attraction between phoſphorus and the oxigen contained in the acid of nitre being ſtronger than that between this principle and nitrous gas.

It was likewiſe in 1780 that he publiſhed his ingenious and uſeful experiments on heat, which were made in conjunction with La Place, the inventor of the inſtrument for aſcertaining the quantity of heat, and on that account denominated the calorimeter. They ſhowed that though the real quantity of heat contained in each body, or the ſpecific heat, is a problem not yet reſolved, yet it may neverthelefs be determined what is the relative quantity of this principle inherent in bodies under like conditions, and between comparable limits. They ingeniouſly applied this calometric method to the quantities of heat diſengaged in the combuſtion of phoſphorus, of charcoal, in the formation of the acid of nitre by pure air and nitrous gas, and in reſpiration; they drew from it important corollaries relative to inflammations and detonations with nitre, to the nature of the blood which abſorbs charcoal by the effect of circulation, and thus depoſits heat, by which a conſtant temperature is ſupported in the regions at a diſtance from the lungs.

58. The year 1781 was a remarkable epocha in the ſeries of the reſearches of Lavoiſier, by the memoir which he publiſhed on the formation

tion of the cretaceous acid, the nature and compoſition of which he had before only ſuſpected. The coincidence of a great number of accurate experiments induced him to aſſert, as a fact well aſcertained, that this acid is compoſed of 0,28 parts of charcoal, and 0,72 of vital air, or rather of what he had, three years before, denominated the oxigen principle. From that time he therefore diſtinguiſhed this acid by the denomination of carbonaceous acid, or acid of charcoal. In this manner it was that he completely explained the production or diſengagement of fixed air in the reduction of metallic calces by means of charcoal.

In 1782, he ardently purſued, in ſeveral memoirs, the application of his new doctrine to ſeveral phenomena of chemiſtry, which he had not before treated, or at leaſt but ſuperficially. He deſcribed the method of greatly increaſing the action of fire and heat, by a current of vital air; he deſcribed the effects of this new method on a great number of bodies, particularly platina and the cryſtal gems. He conſidered the combination of nitrous gas with different reſpirable airs with regard to their relative ſalubrity, and ſhowed that the proportion of vital air to that of the reſpirable fluids could not be aſcertained by this method.

He preſented to the academy ſome general conſiderations on the ſolution of metals in acids; on the calcined ſtate of thoſe metals in ſuch ſolutions, and on the gas proceeding from the acids during the proceſs of ſolution. Theſe were ſucceeded by remarks on the precipitation of metals by each other, in which he ſhowed that it is by the affinity of theſe bodies to the oxigen principle, that they are thus ſeparated from the acids, that which is diſſolved giving out this principle to the other, which aſſumes its place, while the former is depoſited in the metallic form. He even attempted to eſtimate, by this proceſs, by repeating the experiments of Bergmann, the quantity of oxigen contained in each metal united with an acid in the ſtate of calx.

In the ſame year he proceeded ſtill farther in the hiſtory of the combinations of oxigen, by endeavouring to determine the order of its affinities for the different bodies to which it is capable of being united. He followed it in twenty-five different compounds, which he placed in their reſpective order of attraction, with regard to this principle, according to the method adopted for the conſtruction of the tables of affinities.

In another memoir he deſcribed the various combinations of oxigen with iron, according to its ſeveral proportions, and the different ſtates of the calces of this metal. He inſiſted on the difference between the properties produced by the diverſity of the proportions of this principle.

59. It was during the years 1783 and 1784 that he in ſome degree completely eſtabliſhed his new doctrine, by at once extending its applications, and generalizing its principles, by making known to the learned world the facts relative to the decompoſition and recompoſition of water. This brilliant diſcovery, which had ſo many prejudices, ſo many obſtacles and ancient errors to overcome, had been ſuſpected by Citizen La Place, and was already far advanced by Citizen Monge, when Lavoiſier expoſed it in the cleareſt light by the accurate experiments which he publiſhed, by the ingenious machines which he employed in conjunction with Meunier, who glorioully died in the ſervice of the Republic, while defending Mentz, and by the important concluſions he had begun to deduce. Hence he explained the ſource of that inflammable gas, which is obtained during the ſolution of ſeveral metals in acids, and during the decompoſition of vegetable ſubſtances; he explained how and in what inſtances water burns combuſtible bodies, or increaſes their combuſtion when once began; how it effects the calcination of metals; and how this fluid is decompoſed, or formed in a great number of chemical operations.

60. The diſcovery of the nature of water opened a new field for other ſucceſſive diſcoveries, which Lavoiſier continued to make for ſeveral ſucceſſive years; particularly on the abundance of water, furniſhed by ſpirit of wine

and oils in combuſtion; the production of the carbonic acid by water, brought in contact with ignited charcoal; on the water formed by the combuſtion of charcoal, which ſo frequently retains one of the principles of this liquid in its combination; and on the decompoſition of water which takes place in all vegetable ſubſtances, when expoſed to high temperatures.

At the ſame time that he purſued all theſe fortunate applications of the laſt capital diſcovery on the nature of water, from 1783 to the end of 1786, he conceived it neceſſary again to attack, by powerful arguments, publiſhed in ſeveral memoirs during this period, theſe modifications which had, for ſome years, been introduced into the doctrine of Stahl, by ſhowing that a number of different phlogiſtons had been admitted, contrary to the opinion of that celebrated chemiſt, and alſo the new theory of Scheele and Bergmann, by proving that their opinion on the pretended union of phlogiſton with vital air, to form heat, admitted ſuppoſitions without number, and hypotheſes deprived of all foundation and proof.

61. Thus did Lavoiſier, by the uninterrupted labour of fifteen years, by ſucceſſive diſcoveries, by more exact and preciſe reſearches than any that had before been made in chemiſtry, and even by availing himſelf of all the diſcoveries of other chemiſts and philoſophers of his time reſpecting the elaſtic fluids, re-examine all the foundations of the ſcience, regenerate all

its parts: and, after having treated at length on combuſtion in general, on the calcination of metals, on the analyſis of air, on the nature, the formation, and the decompoſition of acids, on metallic ſolutions, on the compoſition of water, on the analyſis of vegetables, on fermentation, reſpiration, &c. objects which embrace the whole ſcience of chemiſtry; he, by this means, eſtabliſhed the durable monument of the pneumatic doctrine, by ſtating the baſe of vital air, which he had defined by the name of oxigen, to act the moſt important part in all the phenomena of nature and art.

SIXTH PERIOD.

Conſolidation of the Pneumatic Doctrine; methodical Nomenclature.

62. IT is eaſy to conceive that ſo great a change as that effected by Lavoiſier,—ſuch an aſtoniſhing reverſe of ideas and principles, could not be eſtabliſhed in the learned world without meeting with great oppoſition, and many objections. Moſt chemiſts and philoſophers at firſt doubted the baſes of the theory propoſed by their cotemporary; and the whole body of chemiſts notwithſtanding his experiments and new reſults, continued to adopt the doctrine of phlogiſton from 1777 to 1787, and to modify ſome parts of it only, according to the example

ample of Macquer. But, after the diſcovery of the nature of water, thoſe who had attentively followed the courſe and progreſs of Lavoiſier, began to coincide with him, and to think that the hypotheſis of phlogiſton ſo far from being neceſſary to explain the phenomena of chemiſtry, is in truth detrimental, and tends to embarraſs the theory.

63. One of thoſe who were moſt aſſiduous among the French chemiſts, and whoſe experiments approached neareſt to the reſults obtained by Lavoiſier, was Citizen Berthollet, who, after having diſcovered the real nature of the pretended dephlogiſticated marine acid diſcovered by Scheele, of the volatile alkali, fulminating gold, fulminating ſilver, as well as the influence of the oxigen principle in the diſcolouring of vegetable ſubſtances, the condenſation of oils, &c. was the firſt who ſolemnly renounced the phlogiſtic doctrine in 1785, and adopted with ardor and attachment the doctrine of Lavoiſier, which he ſoon applied for explaining all the phenomena which he continued to obſerve and deſcribe in his numerous inveſtigations.

64. At the ſame time ſeveral illuſtrious geometers and natural philoſophers of the Academy of Sciences at Paris, as Condorcet, La Place, Couſin, Monge, Coulomb, and Dionis, who zealouſly attended the learned converſations held at the houſe of Lavoiſier, where they were witneſſes of his experiments, and encouraged his efforts, were decidedly in favour of

his doctrine, and found his method of reaſoning far ſuperior to that which had previouſly been adopted in chemiſtry; ſo that this doctrine ſoon became that of moſt of the members of the academy, who propagated and illuſtrated it, by defending it on every occaſion againſt thoſe who attacked it even with a kind of exaſperation.

65. About the cloſe of the year 1786 Citizen Guyton Morveau, who came to Paris to witneſs the lateſt experiments of Lavoiſier and Berthollet, became convinced of the truth of their doctrine by the exactneſs and purity of their experimental reſults. In the midſt of this great movement, which I myſelf had conſidered with attention for upwards of ten years, though till this period I had contented myſelf with being, in the two firſt editions of my Elements of Chemiſtry, ſimply the hiſtorian of the two theories which at that time divided all the chemiſts of Europe, I followed the example of Citizens Berthollet and Guyton. I entirely renounced the hypotheſis of phlogiſton, and adopted in its whole extent the pneumatic doctrine of Lavoiſier. I taught that doctrine alone in my lectures; I inſerted it in my book and in my diſſertations; and at that period the French ſchool was eſtabliſhed, which foreigners denominated Antiphlogiſtian, and of which the moſt illuſtrious philoſophers in Europe ſpeedily adopted either all the data or at leaſt the whole of its principal baſes.

66. United by diſpoſition, by our opinions and our purſuits, Lavoiſier, Guyton, Berthollet, and myſelf, were aware that the revolution effected in chemiſtry demanded of us, in order that it might be preſented in a complete ſtate, and with the clearneſs of the principles it had acquired, a change in its nomenclature. In fact, the ancient terms, invented by obſcure, myſterious, credulous, or enthuſiaſtic individuals, or in the ages of ignorance and barbariſm, or with intentions totally oppoſite to thoſe of a methodical ſcience, without any connection or coherence between them, in many inſtances founded upon prejudice, errors, or opinions more or leſs ridiculous, compoſed an unintelligible language, which preſented to the mind and the imagination, no relation with the things or facts it was intended to repreſent. We perceived the neceſſity of creating a nomenclature entirely new, which ſhould be eſtabliſhed upon the truths lately diſcovered, and free from every thing of an arbitrary or hypothetical nature, as well as of every object foreign to chemical knowledge. To the oxigen of Lavoiſier we gave the name of oxigen to render it more ſuitable to the genius of the French language; to the inflammable principle of water and of all the combuſtible vegetable compounds we gave the name of hidrogen; to the baſe of the non-reſpirable fluid of the atmoſphere we give the name of azote: theſe are

the only words really new which have been thus introduced into the ſcience.

67. To all the acids, in like ſtates, we gave a ſimilar termination; to bodies combined with oxigen without becoming acids, we gave the general denomination of oxides. The combinations of ſimple combuſtibles with earthy, alkaline, and metallic baſes, alſo received an identical termination. We employed with great advantage a ſimple variation in the terminations of words, to denote combinations which are analogous in their nature. Our words all became ſuſceptible of taking, when neceſſary, the character of ſubſtantives, adjectives, or verbs. Subſtances ſimilar in their nature, were deſigned by words of the ſame gender; all the alkalis and earthy bodies received names of the feminine gender; all the metals maſculine: thus we prefixed the French article *le* to platina and manganeſe, as well as to the names of lead, iron, copper, zinc, &c. According to this method of ſyſtematic denomination, the numerous claſs of ſalts became more eaſy to be diſpoſed with regularity, to be claſſed with method, and to be diſtinguiſhed even to their ſpecies; ſo that, far from the apprehenſion that it might no longer be poſſible to retain them in the memory, with their comparative qualities, as the names of men or ſpecific properties which had been given to them gave reaſon to entertain, it was ſoon found that this new language facilitated in a ſingular degree their ſtudy and

their claſſification. Such was the courſe we followed in this undertaking, and ſuch is the ground of the title it has deſervedly received, of a methodical ſyſtem of nomenclature.

68. An incalculable advantage likewiſe ſuddenly reſulted from this work which had become ſo urgent and ſo neceſſary. As we were obliged to preſent in a ſingle table, the repreſentation of a great number of bodies which began to be known in chemiſtry, the productions of nature and art thus became claſſed according to a method entirely different from that which had been before adopted. All the elements of the ſcience were exhibited in this table, and ſtudents derived ſo much advantage from this new claſſification of objects ſo faithfully repreſented, and as it were delineated before their eyes, and rendered ſtriking to the imagination by the nomenclature, that the ſtudy of the ſcience became as eaſy and ſimple as it had before been complicated and difficult.

69. The pneumatic doctrine thus adopted, and propoſed to the learned world by the reunion of the French chemiſts abovementioned, ſoon cauſed the greateſt ſenſation, and threw a great light among all nations in which chemiſtry is cultivated. The nomenclature in which the foundations of the ſcience were traced out, was ſpeedily tranſlated into all languages. In order to render if not the expreſſions, at leaſt the ideas of the original; the idioms, converſions, and particular arrangements

ments required by the genius of each language were adopted; and though the pneumatic doctrine, for ſeveral years after 1787, the date of its conſolidation, met with ſome antagoniſts and opponents in England and Germany, it alſo obtained ſtrong partiſans, ſkilful and zealous defenders in thoſe countries, ſo that it ſoon became generally extended throughout Europe.

70. In England, the celebrated Cavendiſh, Kirwan, Nicholſon, Pearſon, Tennant, &c.; at Edinburgh, the illuſtrious Black, the chief and the Neſtor of this great chemical revolution; in Italy, Dandolo, Volta, Venturi, Spallanzani, &c.; in Germany, Girtanner, Klaproth, Humboldt, Hermbſtædt, Scherer, Schmeiſſer, &c.; in Holland, Deyman Van Trooſtwyck, Lauwerenburg, &c.; in Spain, Prouſt, Chabanon, Arezula; every where, in a word, where this excellent ſcience is cultivated, the ſchools either profeſs no other theory than the pneumatic doctrine, or have adopted its principal fundamental points; and though ſome ſkilful profeſſors, ſuch as Gren, Richter, Göttling, &c. have continued to combine with it a ſmall portion of the ancient phlogiſtic theory, the latter emits only a pale, feeble, and expiring gleam in the preſence of the brilliant illumination of the pneumatic doctrine. I do not here ſpeak of the ſucceſsful applications which are inceſſantly made of this doctrine to all the arts and ſciences; the different branches of chemiſtry which I have diſtinguiſhed in the preceding article, are ſuf-

ficient to ſhow how greatly we are indebted to this doctrine, and how much we have ſtill to hope from its energies.

ARTICLE IV.

On the chemical Nature of Bodies, and the Principles which Chemiſts have admitted into their Compoſition.

1. CHEMISTS have long directed their whole exertions and inquiries to the decompoſition of bodies, in order to aſcertain their elements or conſtituent parts. Hence it was very natural that they ſhould form particular notions or ſyſtems reſpecting the principles which compoſed them. Many experiments have been neceſſary and more particularly a method of reaſoning and philoſophiſing with great accuracy and preciſion, before thoſe poſitive notions on this object could be acquired, which the ſcientific world has poſſeſſed for the laſt twenty years.

2. Thus the early chemiſts, not content with the opinions of the ancient philoſophers reſpecting the elements of bodies and more particularly that of Ariſtotle on the four elements, being alſo deſirous of eſtabliſhing a particular ſchool and ſyſtems in ſome meaſure appropriated to the nature of their works and experiments, admitted five principles in the time of Paracelſus. To every thing volatile and odorant they gave

the name of ſpirit or mercury; ſulphur or oil denoted every thing inflammable; phlegm or water, every inſipid fluid; earth, all that which is dry, inſipid, fixed and inſoluble; ſalt, every thing which is ſapid and ſoluble. A diſtinction of this nature could not long endure, becauſe on the one hand, fire and air were overlooked, and, on the other, the name of principles was given to compound matters, ſuch as ſpirits and ſalts.

3. Becher, a man of a more philoſophic mind, being ſtruck with the looſe and indeterminate effect of the principles of Paracelſus, generalized and added greater ſimplicity to his notions reſpecting chemical principles. He admitted two only, earth and water; the firſt denoting every thing which is dry, the ſecond every thing which is humid. He diſtinguiſhed theſe earthy principles, namely, firſt, vitrifiable earth, or the earth of ſand, of flints, and of rock cryſtal; this, according to him, was the principle of dryneſs, of fixity, of infuſibility, and of hardneſs: ſecondly, the inflammable earth the ſource of combuſtibility. This is the principle which Stahl named phlogiſton, and which he conſidered as fixed fire; and thirdly, the mercurial earth, the principle of volatility and of gravitation at the ſame time, which he admitted in mercury, in the metals in general, and in ſome other bodies. This laſt hypothetic product of his imagination could never be proved to exiſt by Stahl, though he, with great ingenuity,

nuity, rendered the exiſtence of his inflammable earth probable.

4. After the time of Becher and Stahl, and more eſpecially after the labours of Boyle and Hales on elaſtic fluids, chemiſts again admitted the four elements of Ariſtotle in the compoſition of all bodies which had been ſuppoſed to be formed of that number of principles, namely, fire, air, earth, and water. Nevertheleſs, ſome chemical philoſophers while they preſerved to theſe four ſubſtances the name of elements, before the epocha of that chemical revolution which has proved that three of them have not the properties of true elements, were careful to diſtinguiſh the principles which they conſidered as ſtill more ſimple than thoſe elements themſelves, and affirmed to be their conſtituent parts. This opinion which approached that of the ancient philoſophers reſpecting the monades and atoms, was the more hypothetical in one reſpect, and unfounded in another, becauſe while they thus admitted elements of elements, beings which their experimental proceſſes were very far from exhibiting or even juſtifying a ſuppoſition of their exiſtence, they qualified, at the ſame time, with the name of principles, thoſe ſubſtances of great complication which they obtained immediately from vegetables.

5. It is true, that in this method of diſtinguiſhing the principles, and, in order to produce a kind of arrangement and apparent perſpicuity in their diſtinctions, the ſame chemiſts

admitted primitive and ſecondary principles, proximate and remote principles, principiant and principiate principles; expreſſions which have become obſolete ſince the revolution in chemiſtry, but of which it is, nevertheleſs, neceſſary to form ſome conception in order to underſtand the books of chemiſtry, and to form an accurate notion of the means by which we have gradually ſucceeded in aſcertaining the inutility and even the danger of ſuch diſtinctions.

The primitive principles were ſuch as could not be decompoſed; they were the original component parts of bodies: the ſecondary principles were themſelves compoſed of the primitive, though they were obtained from the decompoſition of ſubſtances ſtill more compounded. Thus we may obſerve, that under the ſame name were confounded ſimple bodies and others of greater complexity.

The ſame error exiſted in the two other diſtinctions of principles which were in fact merely ſynonimous variations of thoſe two firſt denominations. The proximate principles were ſuch as are obtained from a firſt or immediate decompoſition; the remote principles, which formed by their union the proximate principles, were obtained only by the decompoſition of theſe laſt. Theſe were alſo named principiate and the others principiant principles. It is evident, that every clear idea of ſcience muſt have been confounded and overturned by diſtinctions of this nature.

6. Macquer was not more happy in his determinations, or rather in the propoſitions which he offered upon this object. For as he directed his attention to amend the terms without rectifying the notions they repreſented, and as he perpetually confounded objects really diſtinct or even diſcordant, he was deſirous that the principles ſhould be denominated according to their order of compoſition and of the compounds which afforded them, by the appellations of principles of the firſt, of the ſecond, and of the third order. But, in this method, the erroneous denomination of principles was conſtantly applied to compounds more or leſs multiplied, and error was propagated: becauſe, if we aim at the abſolute diſcovery of the principles, we ought not to admit of more than one order; it being evident, that when they are once united together, they do no longer in truth belong to the claſs of principles, but to that of compounds.

7. At preſent we have renounced all theſe abuſive, arbitrary, and erroneous diſtinctions. It is admitted, that if the word principles be applied only to the firſt conſtituent particles of all bodies, they are perfectly and entirely unknown; that they cannot be the objects of our ſenſes, and that we ſhould employ ourſelves in mere ſuppoſition and vague arrangement, if we were to attempt to determine their nature, their number, or their differences; and, in a word,

that a true philoſopher ought to abandon all theſe abſtract notions which have been diſſeminated at different periods on this ſubject.

8. It is alſo known that if we underſtand by elements (a denomination ſomewhat more preciſe than that of principles, though it has ſometimes been confounded with, and ſometimes diſtinguiſhed from them) ſuch ſimple or undecompoſed bodies as are found in the decompoſition of all others, there are a much greater number of elements or matters which poſſeſs theſe two united characters, than the pretended elements admitted previous to the time of the chemical revolution; and that among thoſe four bodies, which have ſo long been conſidered as elements, there are three at leaſt, which, ſo far from being undecompoſed ſubſtances, do preſent a decompoſition more or leſs eaſy, or varieties more or leſs numerous. Every motive therefore requires, at the preſent period, that we ſhould renounce the ancient ideas reſpecting principles as well as elements, and that we ſhould uſe theſe two denominations only comparatively, and without attaching to them that exact, determinate or limited value which has formerly been attributed to them.

9. It was not alone reſpecting the principles and elements of bodies, that vague, obſcure, or uncertain notions were entertained: the concluſions adopted reſpecting the different claſſes of compound bodies, or the comparative differences of their compoſition, were equally in-

accurate. The mere enumeration of the words which were adopted to expreſs them, will ſerve to give a proper notion of this ancient diſtinction. The compounds formed by the union of two or more elements, was called a mixt; and, as all bodies were for a long time regarded as reſulting from the immediate combination of the four elements, the word mixt, ſo often uſed in chemiſtry, was nearly ſynonimous with that of body; ſo that this term alone deſignated almoſt every one of the orders of compounds. When an attempt was made to introduce more accuracy into theſe denominations, the word mixt was confined to the union of two elements; the word compound was applied to the combinations of two mixts; ſur-compounds to the union of two compounds; decompounds to ſuch as were formed of two ſur-compounds; and ſur-decompound was applied to denote the maſs formed of two decompounds. Not to mention that theſe denominations were calculated only to embarraſs and over-charge the language of philoſophy; they were alſo mere futile and imaginary diſtinctions, becauſe it was impoſſible to give any inſtances, in point of fact, but thoſe of compounds and a few ſur-compounds. So that though the expreſſions were detailed in the elements of ſcience, they were not uſed in any of its developments.

10. Macquer, in order to expunge theſe barbarous and tireſome denominations, propoſed the clearer terms of compounds of the firſt, ſecond,

cond, third and fourth order. In the preſent ſtate of the ſcience we ſeldom have recourſe to theſe terms. It is more uſual to employ the expreſſion of binary compounds to denote the union of two ſimple bodies; ternary for that of three; quaternary for that of four ſimple bodies; and it is agreed to apply the expreſſion of ſimple bodies to thoſe only which, not being decompoſable by the chemical methods, are admitted as forming, by their more or leſs numerous union, all the natural compounds.

Article V.

Concerning the Separation of the Principles of Bodies, or the Chemical Analyſis.

1. WHEN it was aſcertained that many natural bodies are compounded of different principles, or other bodies ſtill more ſimple, methods were ſucceſſively employed to ſeparate the principles from each other. The name of analyſis was given to the art of effecting this ſeparation; an expreſſion which, ſince its adoption by chemiſts, has been received in every branch of human knowledge to denote the ſeparations and decompoſitions, even in the order of our ſenſations and our ideas.

2. The obſervations which have been gradually accumulated on the art of analyſing compounds, and obtaining their principles, have

induced

induced the neceſſity of aſcertaining and diſtinguiſhing ſeveral different kinds of analyſis, either from the method of operation, or the reſult obtained, or from the nature of the bodies to which the ſame are applied. In order to underſtand theſe diſtinctions we muſt remark, that thoſe matters which are ſeparated by analyſis, whatever they may be, are diſtinguiſhed by the general name of products, becauſe they are not always principles.

3. Under the firſt point of view we might diſtinguiſh a conſiderable number of analyſes, and carry it to as great an extent as there are differences in bodies, or in the proceſſes which ſerve to analyſe the compounds. Nevertheleſs, we may, by generaliſing this firſt mode of diſtinction, admit four kinds of analyſes: the mechanical analyſis, the ſpontaneous or natural analyſis, the analyſis by fire, and the analyſis by re-agents.

4. I call that the mechanical analyſis which, by mechanical means, ſuch as pounding, waſhing, or preſſure, affords the leſs complicated matters contained and mixed in more compounded bodies. In this manner the gums, the juices, the oils, and the farina of vegetables are ſeparated. It is only a kind of diſſection, a commencement of analyſis, rather than a true chemical analyſis; but as this mode of ſeparation is indiſpenſable, and muſt precede every other ſeparation in the bodies to which it is applicable,

plicable, it muſt be carefully diſtinguiſhed from all the other methods.

5. The ſpontaneous or natural analyſis is that which is operated by the mere efforts of nature, and of which the chemiſt often avails himſelf to know the compoſition of bodies. Thus it is that minerals or foſſils become ſpontaneouſly altered, and mutually ſeparate from each other within the earth or at its ſurface; thus it is that vegetable or animal matters are ſlowly decompoſed when deprived of the vital motion; and thus alſo the principles of moſt liquids of a compounded nature, when left to themſelves, re-act upon each other, and by ſpontaneous ſeparation, afford the obſerver very much information reſpecting the compoſition of thoſe bodies.

6. The analyſis by fire is that which is effected by the accumulation of caloric in bodies, and by the power it has of ſeparating the various particles, and of favouring their mutual diſengagement. This was formerly ſo much uſed, that it was long thought to be the only power within the reach of the chemiſt. This kind of analyſis, however, has given riſe to great errors; and it was not 'till the revolution of the ſcience, and the commencement of the pneumatic doctrine, that we have been able to aſcertain with preciſion the effect of this agent on a great number of bodies. We no longer conſider this analyſis but as one of the means which ought to be joined with many others to exhibit the true compoſition of bodies. It is

more particularly aſcertained, as will be ſeen in the following ſection of this work, that the various quantities of caloric, accumulated in bodies, have ſo great an influence on the order of their decompoſition, that we may even admit a kind of analyſis by cold.

7. The analyſis by re-agents is that which is obtained by placing the compound required to be examined in contact with a ſeries more or leſs numerous, of ſuch other bodies as by re-acting upon it favour the ſeparation of its principles. This method has no other limits than that of the genius and information of the chemiſt. He may employ all the bodies of nature and all the products of his art. Every thing in his hands becomes a re-agent provided he is well acquainted with, and has previouſly determined the mode of action of theſe bodies upon that which he is deſirous of analyſing. We might affirm, on comparing the foregoing methods of analyſis to the preſent, that they are of the ſame nature, becauſe fire is truly a re-agent; but it is neceſſary to diſtinguiſh them on account of the different uſe which chemiſts make of each in particular caſes, and the different degrees of confidence they repoſe in the one or the other.

8. When we conſider the difference of the analyſis with regard to their reſults, we muſt diſtinguiſh the immediate or proximate analyſis from the mediate or remote; the ſimple or true analyſis from the complicated or falſe.

Theſe four kinds of analyſis require to be preciſely diſtinguiſhed, becauſe they frequently preſent themſelves in chemiſtry, and afford very different reſults with regard to the knowledge of the compoſition of bodies.

9. I call that the immediate analyſis by which the firſt ſeparation of the ſubſtances forming more complicated compounds is made; ſuch is that which is uſed for vegetables more particularly in the firſt mechanical treatment. To form a proper idea of this, we muſt underſtand that the bodies, to which it is applied, are formed of a mixture of ſeveral compounds, which muſt be ſeparated from each other before they can be individually analyſed. In this manner it is, that we firſt extract from the juice of a plant the fecula, the mucilage, the ſugar, and the proper ſalt contained therein which are themſelves compound bodies, capable of having their peculiar nature exhibited by a new analyſis. It is by treating them proximately or immediately by the firſt chemical means, that we obtain theſe firſt materials of their compoſition, and hence is derived the name which I give to this kind of analyſis. We ſee that it ought to precede all the others. It differs from the mechanical analyſis becauſe it almoſt always follows it, and becauſe the means made uſe of in this are frequently different from thoſe of the mechanical proceſs,

10. In oppoſition to the foregoing, I call that the mediate or remote analyſis, which, ſuc-

ceeding to the proximate analyſis, examines the nature of the firſt compounds which are obtained by this laſt in order to aſcertain their intimate compoſition. This is entitled to the name I have given it only with reſpect to the immediate or proximate analyſis; it muſt only be diſtinguiſhed from that analyſis by a kind of oppoſition, and, in order to form an accurate notion of the different kinds of decompoſition which can be effected in bodies. It may be claſſed among the different kinds of analyſis which we have conſidered with regard to their means, becauſe it is, in fact, by theſe different means that we are capable of making this kind of remote analyſis.

11. The third kind of analyſis, with regard to the reſults afforded by theſe proceſſes, is diſtinguiſhed by the name of the ſimple or true analyſis, becauſe it gives the products without alteration, ſuch as they exiſted in the compound which afforded them. The character by which this kind of analyſis is diſtinguiſhed, is that the products it affords being re-united, form again the compound ſuch as it was in its nature and quantity before its decompoſition. We ſee that it is on account of this character that it is called true or ſimple; true, becauſe it gives reſults which are without error, and ſimple, becauſe the effects which accompany it, or to which it gives riſe, are not complicated. This kind of analyſis is the moſt uſeful and alſo the moſt rare; it demands much of accuracy and

much of labour, and accordingly it is that to which we do not arrive but in the laſt ſtage of our operations, and after having tried all the others.

12. The fourth kind of analyſis, conſidered with regard to its reſults, is oppoſed to the foregoing; and therefore, I call it falſe or complicated, becauſe it forms products which are altered, and different from what exiſted in the compound of which their elements conſtituted a part. It may appear difficult, on firſt conſideration, to form a notion how we can obtain from a compound products which are not really contained in the ſtate they poſſeſs when ſeparated from the body itſelf. But this difficulty is only apparent, and ceaſes to be ſo when the cauſe is explained, It is owing to the circumſtance that the very complicated compounds to which this kind of analyſis is applied, containing a great number of principles united together at the ſame time, allow to each of them when ſeparated, the facility of combining in a number and order which are different from thoſe of their primitive combination. That is to ſay, inſtead of a quartenary compound which originally exiſted, and in which the four component principles were united altogether, there is formed by the kind of analyſis here treated of, two new binary compounds, different from the firſt compoſition; ſo that when they are reunited, we can no longer produce that original compound, This effect happens, for example,

ple, in the analyſis by fire applied to vegetable or animal matters.

13. The falſe or complicated analyſis, of which the denomination muſt be well underſtood after the explanation here given, is unfortunately the moſt frequent of thoſe which chemiſts are obliged to employ; but in cauſing new methods of analyſis to ſucceed each other upon each of the products afforded, they arrive, at length, to the true or ſimple analyſis, the term of their labours and the aim of their expectation. Hence, we ſee, that it is only by applying ſucceſſively thoſe analyſes which differ either by their means or by their reſults, that we can ſucceed in accurately determining the order of compoſition of bodies, and the nature as well as the quantity of their principles.

14. Laſtly, by conſidering the chemical analyſis under the third relation of bodies to which it can be applied, we diſtinguiſh more particularly the mineral analyſis, when it has for its object the knowledge of foſſils; the vegetable analyſis; and the animal analyſis, when theſe proceſſes are applied to ſubſtances of the reſpective claſſes of organized ſubſtances. But, it is obvious, that we might multiply the ſpecies of this genus to a much greater extent, if we were to proceed as is often done in ſyſtematical works, laboratories, collections, &c. and diſtinguiſh the analyſis of earths, which are ſo uſeful to agriculture and a multitude of arts; the analyſis of ſtones, ſo advantageous to

the architect, the ſculptor, the engraver, the jeweller, &c. the analyſis of ſalts, of ores, of water, &c. But as each of theſe denominations carries with it its preciſe definition, and, as they may alſo be as various as the demands of the ſciences and arts which require them, it is uſeleſs to dwell any further upon this ſubject.

15. As the diſtinctions of the various kinds of analyſis are neceſſary to him who is deſirous of knowing the reſources of chemiſtry and its advantages; as it is indiſpenſable to eſtabliſh them with preciſion, at the commencement of the ſtudy of this ſcience, ſo likewiſe they poſſeſs another kind of utility, when we apply preciſe concluſions to the comparative nature of the different products hitherto ſubjected to theſe different kinds of analyſis; they teach us that bodies, conſidered with regard to the analyſis which may be made of them, are diſtinguiſhable into three great chemical claſſes. The firſt claſs is that of bodies not yet decompoſed or indecompoſable, and comprehends thoſe upon which no analyſis has any effect, and of which no diſtinct principle can be ſeparated; ſo that chemiſts conſider them as if they were ſimple, and ſometimes deſignate them by that expreſſion. The ſecond includes bodies decompoſable without alteration, and comprehends all thoſe to which the true or ſimple analyſis can be applied, and which afford products ſuch as they exiſted in the compounds of which they conſtituted part. The number of bodies which are ſuſceptible

tible of theſe proceſſes is not very conſiderable. The third claſs comprehends bodies decompoſable with alteration, and embraces the numerous ſeries of compounds which, when ſubjected to analyſis, afford products likewiſe compounded but different from their ſtate of exiſtence in the firſt compoſition.

ARTICLE VI.

Concerning the chemical Combination of Bodies with each other; or Syntheſis.

1. THE different methods of analyſis which chemiſts have uſed in order to acquire a knowledge of natural compounds, have obtained ſo much confidence, and rendered ſervices to ſcience of ſuch magnitude, that chemiſtry itſelf has frequently been deſignated as the ſcience of analyſes. Neverthelefs, when we carefully compare the reſults of theſe analyſes, it is ſoon obſerved, that in many of the caſes which appear to be analytical, from the ſeparation or diſunion of the principles of compounds, no other proceſs has in reality been effected, than a different kind of union among the parts or principles, with regard to their number or proportion.

2. On the other hand, it was obſerved, that when various bodies are placed in contact with each other, two and two, or three and three,

they frequently are confounded together and form one ſimple whole. This new totality formed by the union of various bodies, effected by means of art, is diſtinguiſhed by the name of compoſition or combination.

3. This union, of which the reſult is a compound, has become a powerful means for aſcertaining the properties of bodies and forming a great number of products uſeful to our wants and the arts;—Hence it is, that chemiſts by oppoſing this method of operating to the method of analyſis of which it is to a certain extent the inverſe, and conſidering it as one of the extremes of their art, as one of the great means of their operations, have carefully diſtinguiſhed it by the name of ſyntheſis.

4. Under this laſt point of view, the word ſyntheſis, though often confounded with the terms compoſition or combination, is not really ſynonimous but denotes another thing. In fact, we may apply the word compoſition or combination to the product of this mode uſed by chemiſts to compoſe or combine, and reſerve the word ſyntheſis for the operation itſelf, or power of which the operator, in a certain reſpect, avails himſelf when his intention is by experiment to unite together ſuch bodies as he knows are capable of that proceſs. It is nevertheleſs neceſſary, that the ſtudent ſhould be aware that the words compoſition, combination, and ſyntheſis, are very often uſed indiſ-

criminately for each other in writings and converſations upon chemical ſubjects.

5. Syntheſis, conſidered as the ſecond general method of chemiſtry, to aſcertain the intimate and mutual action of natural bodies, is ſtill more frequent than analyſis, and the ſcience, if it were to be defined from the uſe of its two means of operating, would be rather entitled to the name of the ſcience of ſyntheſis, than that of analyſis, becauſe, in all the caſes of complicated analyſis, we operate in truth only by ſyntheſis, and form merely compounds of an order indeed inferior, but likewiſe in number ſuperior, to that of the firſt compounds ſubjected to this kind of analyſis.

6. Syntheſis is ſtill more entitled to enter into the definition of the ſcience; and, in this reſpect, would be preferred to analyſis, becauſe many natural bodies not being capable of decompoſition, and obeying no other power than that of union or ſyntheſis, there is no other method of acquiring a chemical knowledge of them, than by combining them with each other and examining the compounds formed by this kind of combination.

7. From the preceding obſervations we ſee, that as the name of compoſition is often uſed inſtead of that of ſyntheſis, the word decompoſition may alſo be ſubſtituted for that of analyſis, and accordingly we find that this is frequently done in treatiſes of chemiſtry.

8. However varied the operations of chemiſtry may be, however numerous and different from each other the reſults may be obtained, they are all referable to analyſis or ſyntheſis, and muſt be conſidered as compoſitions or decompoſitions. Every thing which this art is capable of accompliſhing may be comprehended under theſe two general methods, and moſt frequently they are combined together. Such is the accurate notion which we ought to entertain of the falſe or complicated analyſis, of which the origin and the products, though foreign in a certain reſpect to the firſt compounds which afford them, are, in truth, produced by a ſeries of combinations or ſyntheſes, which are effected at the ſame time that the decompoſition takes place.

Article VII.

Of the Attraction of Aggregation.

1. ALL the operations of chemiſtry are founded on the force of attraction, which nature has eſtabliſhed between the particles of bodies; this force, which retains the planetary bodies at determinate diſtances, alſo retains the particles of bodies in the vicinity of each other. When we conſider it as operating between ſimilar particles, or thoſe of like nature, it bears the name of attraction of aggregation.

2. It is not this force of aggregation which chemiſts employ to operate their analyſes or ſyntheſes. It even oppoſes itſelf to the effects they are deſirous of producing; and as they are obliged, on account of this very oppoſition, to deſtroy or to diminiſh it, it becomes eſſential that they ſhould carefully acquire a knowledge of, and be able to eſtimate its power, in order to determine the neceſſary means of overcoming it.

3. In the early periods when chemiſts perceived that the force here mentioned oppoſed their operations, being habituated to explain the effects, they obſerved, by certain relations or analogies, which they ſuppoſed to exiſt between bodies, they named this force the affinity of aggregation.

4. The Affinity of aggregation of the chemiſts is nothing more than the attraction which exiſts between particles of like nature adhering to each other. Its effect is well expreſſed by the words adheſion or coheſion, though theſe words may themſelves be diſtinguiſhed and conſidered in truth only as ſynonimous terms.

5. Two ſolids, moiſtened and placed in contact, adhere or attract each other with a force which frequently varies according to the particular nature of each. Thus a metal adheres more ſtrongly to another metal than to a liquid which is not metallic, &c. We muſt not confound this phœnomenon with that of ſimple floating bodies, or needles placed upon water

which attract each other, in the caſe, when the two bodies are either unequally moiſtened, or equally diſpoſed to reſiſt moiſture, and which repel each other conſtantly, when one of them is capable of being wetted and the other is not; this laſt effect, which is the cauſe of the aſcent of water in capillary tubes, depends on the convex or concave ſurface formed in the water. In either caſe it is referrible to the doctrine of inclined planes, though it has been conſidered by ſome as an example of the attraction of coheſion.

6. As it is a conſtant fact that bodies attract each other at a diſtance, and as a number of experiments prove at the ſame time that all bodies abound with ſmall cavities or pores more or leſs numerous, we may conſider the attraction of aggregation which brings the particles of bodies together, as the power which holds them only at certain diſtances from each other ſo that they do not touch, but leave between each other intervals of greater or leſs magnitude.

7. From the exiſtence of this attraction between ſimilar particles, the bodies thus produced are called aggregates, in oppoſition to the words heap, maſs, or mixture, which denotes bodies whoſe particles being ſeparate from each other do not form aggregates. A piece of ſulphur is an aggregate; ſulphur in powder is merely an heap.

8. As all the particles connected or kept together by the force of aggregation, in an ag-

gregate, are of the ſame chemical nature, they have been diſtinguiſhed by the name of integrant particles to diſtinguiſh them from the conſtituent parts which are ſeparated by analyſis. Thus each integrant particle of a binary compound is formed of at leaſt two other particles, one of one kind of principle, and the other of another kind of principle. This diſtinction is eſſential with reſpect to all the known compounds, but it is of no conſequence with regard to indecompoſable bodies in which, while we conſider them as ſimple, we may take the integrant particles to be of the ſame nature as the conſtituent parts.

9. When we compare bodies with regard to the difference of their aggregation they are diſtinguiſhed into four kinds of aggregates; the ſolid aggregate, the ſoft aggregate, the liquid aggregate, and the gaſeous aggregate. Theſe four aggregates are conſequences of different degrees of the ſame force; which has its maximum in the denſiſt ſolid, and its minimum in the rareſt and lighteſt gas. This opinion is founded on the fact, that we are able, by means of the accumulation of caloric in a body, to cauſe it to paſs ſucceſſively from the ſtate of a ſolid aggregate to thoſe of the ſoft, the liquid, and the elaſtic fluid aggregate. We can even, by withdrawing the accumulated caloric, cauſe the aggregation to appear again in all its force and convert a gas into a liquid, and that liquid into a ſolid.

10. Every genus of thoſe aggregations comprehends a great number of ſpecies or degrees of ſolidity, ſoftneſs, liquidity, or gaſeity, which in each of theſe ſtates may, in ſome inſtances, be more remote from each other than the genera themſelves, notwithſtanding their apparent difference. Thus, among ſolids, we diſtinguiſh, beſides their regular or organic form, the ſpecies, and even the mode of ſolidity, by the different degrees of denſity, hardneſs, tenacity, ſpecific gravity, elaſticity, brittleneſs, ductility, &c. Among liquids, beſides the variations of denſity and weight, the different modifications of aggregation are deſcribed by the words conſiſtence, thickneſs, viſcidity, unctuoſity, &c. In the genus of gaſes the ſpecific gravity and dilatibility are the only meaſures of their rarity, becauſe they elude the ſight, and afford fewer ſenſible properties to appreciate the ſhades of difference between them.

11. Theſe notions having, in truth, no relation with any chemical principle but that of the deſtruction of aggregation, it is eaſy to imagine that, in order to produce this laſt effect, nothing elſe is required to be done but to apply a force to the aggregates, that is to ſay, preſſure, or a blow, the energy of which ſhall be more conſiderable than the force of aggregation itſelf. This is done in all the preparatory operations of dividing, chopping, pulverizing, levigating, or filtering the different natural bodies, whether for the purpoſe of reducing

ſolids into particles ſo ſmall and ſeparate, that the force of aggregation ſhall become inconſiderable; or to ſeparate liquids from the different ſubſtances which affect their purity, by rendering them turbid.

12. The art of chemiſtry which, in the different means it employs to deſtroy the aggregation of bodies, has really for its object, to cauſe theſe bodies to paſs from the ſtate of phyſical ſubjects (that is to ſay, ſubjects of which the mechanical philoſophy can aſcertain their properties) to that of chemical ſubjects, on which this philoſophy may be conſidered as no longer operating, poſſeſſes and alſo employs the means of cauſing them to appear again in their ſtate of aggregates; when, after having ſubjected them to the action of different agents, it is deſirous of knowing their phyſical properties, and preſerving them under their true form. They are then obtained under the figure of an irregular maſs, more or leſs conſiſtent, or in thoſe regular figures which are called cryſtals.

Article VIII.

Concerning the Attraction of Compoſition.

1. CHEMISTS can make no ſynthetical nor analytical operation, if they do not carefully ſtudy the effects which ariſe from the attraction of compoſition. It is this force which produces,

duces, and ought to direct all the operations of our laboratories. It is this power which imparts the knowledge of the intimate and mutual action of all the bodies of nature upon each other, and conſequently renders us acquainted with their chemical properties. The entire collection of the phenomena to which it gives birth, do in effect conſtitute the ſcience itſelf, which conſiſts merely in the arrangement and ſyſtematical connection of the whole of theſe phenomena.

2. The attraction of compoſition, which was formerly called chemical affinity, becauſe it was ſuppoſed to be produced by a natural relation between the bodies in which it is obſerved, differs from the attraction of aggregation in the circumſtances, that this laſt never acts but between ſimilar particles, and affords merely coherent maſſes of greater volume or denſity, but of the ſame nature as thoſe parts themſelves; whereas the attraction of compoſition exiſts only between thoſe diſſimilar particles of which the union and adheſion forms chemical compounds. This explains the origin of its name.

3. The creating power of nature has placed, in all the bodies which compoſe our globe, and probably alſo in thoſe which belong to the other maſſes of the whole univerſe, an intimate force, which penetrates them, agitates their particles, and, as it were, cauſes them to join each other, or at leaſt to approach ſo very nearly together, and adhere with ſufficient ſtrength

to form ſubſtances different from what they individually were before their union. Whence it follows, that the chemiſt, by cauſing the attraction of compoſition to act between natural bodies, is only the miniſter or director, and does nothing more than obſerve the effects reſulting from theſe operations. It is alſo, on account of this tendency to union, an expreſſion ſometimes uſed to denote the attraction of compoſition, that the earlier chemiſts, who were deſirous of explaining its cauſe, have ſuppoſed between the particles of bodies a kind of friendſhip or affection, from which is derived the word affinity, ſo long employed to expreſs this natural phenomenon.

4. When we conſider the whole ſeries of phenomena ariſing from chemical attraction, or the attraction of compoſition, we obſerve, that thoſe which are proper to deſignate its character, and conſequently to throw the greateſt lights on the theories of ſcience, are at the ſame time ſo conſtant, that moſt chemiſts, in conformity to the propoſition I firſt made in 1781, have thought proper to diſtinguiſh them by the name of laws.

5. We may at preſent diſtinguiſh ten general laws of the attraction of compoſition, the conſideration of which ſufficiently ſhows the great influence of this force, in all the phenomena of nature and of art, and conſequently on all the reſults of the operations of chemiſtry. As each of thoſe forms a true chemical

axiom, proper to explain all theories of the ſcience, we ſhall not merely recite them in this place without explanation, but by announcing them in ſucceſſion we ſhall ſhow how many important applications each of them is ſuſceptible of, and its relation to the whole doctrine of the ſcience.

6. The firſt law of the attraction of compoſition, is *that it takes place only between bodies of different nature or diſſimilar particles.* The perſpicuity and generality of this law are ſeen in its ſimple enunciation; for it is evident that an attraction, ſuppoſed to take place between ſimilar bodies, would be merely that of aggregation, and could never form compounds. Though moſt chemiſts have apprehended that what has been called affinity between bodies muſt be the effect of a relation or intimate ſimilitude between them, the phenomena of chemiſtry prove, nevertheleſs, that the attraction of compoſition is ſtronger in proportion as the nature of the bodies between which it is exerted is more remote; as far as we are able to aſcertain or appreciate this difference.

7. The ſecond law, *the attraction of compoſition takes place only between the ultimate particles of bodies.* In this expreſſion the doctrine already exhibited is ſhown in a new form, namely, that it is neceſſary that bodies ſhould be in an extreme ſtate of diviſion, and have paſſed from the rank of phyſical ſubjects to thoſe of chemical; that they ſhould have loſt their ſolid

conſiſtence or ſtate of aggregation, in order that they may be able to unite, ſo as to form a compound; for it is between the conſtituent particles of bodies that the attraction of compoſition is exerted; and conſequently it is evident that the movement by which they are carried toward each other, in order that they may approach ſo near as to combine, or the very act of this combination muſt eſcape our ſight. When therefore we explain, that it reſides only in the ultimate particles, and that it is totally different from the attraction of aggregation which takes place only between the groſſer particles, which, for this reaſon, are called integrant parts, the terms of this law affirm, at the ſame time, that the mode of its operation, the motion which accompanies it with the elements of form, diſtance, and weight, which direct it, are concealed, with reſpect to us, under an impenetrable veil; and that man can know them only by the reſults, without being able to eſtabliſh any computation reſpecting the data themſelves.

8. The third law, *the attraction of compoſition can take place between a number of bodies.* The enunciation of this law, though very ſimple, comprehends nevertheleſs all the poſſible combinations and the true aggregate of chemical reſults; ſince it teaches us that 57 bodies not decompoſed, if conſidered as to the poſſible number of their chemical compounds, taking them 2 and 2, 3 and 3, 4 and 4, and 5 and 5,

without carrying them to a more elevated complication muſt afford 4,612,972 compounds; a quantity of which it is almoſt impoſſible to conceive that the human mind can embrace the ſeries and compariſon of characteriſtic properties.

9. The fourth law. *In order that the attraction of compoſition may take place between two bodies, it is neceſſary that one of them, at leaſt, ſhould be fluid.* Though, in this place, we aſſert nothing more than that it is neceſſary to employ, in the operations of chemiſtry, ſuch bodies only as have no power of aggregation, yet it is of importance to conſider and attend to this law in particular; 1. becauſe it forms an ancient chemical axiom, *corpora non agunt niſi ſoluta*, of which we ought to know the value; 2. becauſe its examination leads us to the knowledge of one of the great phenomena which takes place in chemical operations. As, according to the tenor of this law, it is ſufficient that one of the two bodies ſhould be in the fluid ſtate, it happens that, by preſenting a ſolid body to a liquid, we ſee, during the very act of their combination, the ſolid diſappear, and become fuſid, by partaking the liquidity of the fluid; and this is named ſolution. There exiſts, conſequently, in this force, a power of ſufficient magnitude that the attraction of aggregation of one of the two bodies ſhould be deſtroyed by its energy.

10. Chemiſts have long exhibited falſe ideas of ſolution. This was done, not only by diſtinguiſhing one of the bodies by the denomination of the ſolvent, and the other that of the ſolvend; a diſtinction which, in fact, expreſſes merely the ſolid ſtate of the one, and the liquid of the other with their tranſition; but alſo by erroneouſly attributing to the ſolvent a particular force, virtue or power, by the admiſſion of which it was ſuppoſed that all the effect of ſolution depends on the liquid, while the ſolid itſelf appeared to be a paſſive kind of body, which was ſubjected to diviſion, deſtruction, or, in a word, ſolution, by the former. This proceſs of reaſoning was afterwards carried ſo far as to imagine that the ſolvent had the form of needles, while the body to be diſſolved was filled with pores; and that the needles entered into the pores, and ſeparated the parts of the ſolvent. This mechanical explanation of ſolution is not only a ridiculous fiction; but a very falſe interpretation of the phenomenon itſelf to which it was applied.

11. In fact, there is no more effort in ſolution, on the part of the liquid than on that of the ſolid. The ſolid is carried with as much power and activity towards the parts of the fluid, as theſe laſt are towards the ſolid. The tendency to union between both is equal, and we might even, perhaps, be permitted to ſay, that the ſolid employs more force to loſe its aggregation than is employed by the liquid in

deſtroying it. And, moreover, though the liquid imparts its fluidity to the ſolid, the particles of this laſt, in proportion as they are ſeparated and interpoſed between thoſe of the liquid, tend alſo to impart their ſolidity, and to give a degree of denſity, ſpecific gravity, and conſiſtence, more or leſs, exceeding what it poſſeſſed before. Thus, in every ſolution, before the ſolid becomes liquid, part of the liquid itſelf becomes ſolid by interpoſition between the particles of the ſolid itſelf. Accordingly, in many of theſe operations we ſee the liquid partaking the ſolidity of the ſolid, inſtead of producing liquefaction in the ſolid itſelf.

12. The fifth law. *When ſeveral bodies unite or combine, their temperature changes at the very moment when the attraction of compoſition acts between them.* As we cannot, in this place, attend to more than a ſimple general expoſition of the laws of chemical attraction, the full explanation of the cauſe of this effect will be given elſewhere. It muſt only be obſerved, that whenever two or more bodies attract and combine chemically, their temperature is either raiſed or lowered, and never remains the ſame at the moment of their union. There is conſtantly either a production of ſenſible heat or a refrigeration in the very act of combining; ſo that a chemical compound muſt always retain a greater or a leſs portion of caloric than the ſum of that which its component parts contained before their union. This habitude, which

hereafter we ſhall call the capacity for caloric, or the ſpecific heat of the body, is therefore changed in the act of combination, and the combined bodies are in another condition with regard to the proportion of this principle, than they were before the combination of the principles which form them. We muſt here confine ourſelves to this ſimple expoſition, and only remark, that all compounds, which at the moment of their formation become hot, loſe caloric, and afterwards retain leſs than was originally held by their component parts; whereas, on the contrary, all thoſe which, at the inſtant of their formation become cold, do abſorb caloric, and contain more than their principles held before their union.

13. The ſixth law. *Compounds formed by chemical attraction, poſſeſs new properties different from thoſe of their component parts.* It is the more neceſſary to have a clear conception and decided explanation of this conſtant phenomenon, or law of the attraction of compoſition, becauſe chemiſts have long believed that the contrary took place in their combination. They thought, in fact, that the compounds poſſeſſed properties intermediate between thoſe of their component parts; ſo that two bodies, very coloured, very ſapid, or inſipid, ſoluble or inſoluble, fuſible or infuſible, fixed or volatile, aſſumed, in chemical combination, a ſhade of colour, or taſte, ſolubility or volatility, intermediate between, and in ſome ſort

compoſed of, the ſame properties which were conſidered in their principles. This is an illuſion or error which modern chemiſtry is highly intereſted to overthrow. We never can regard the properties of a compound as the middle term of their compoſition. We ſhould never arrive by any calculation or eſtimate from the properties of one or more bodies to determine thoſe which they would have when combined. Thus bodies abſolutely inſipid before their union, become acrid and cauſtic afterwards; colourleſs bodies form very coloured compounds and the contrary; matters abſolutely infuſible become very fuſible by their union; bodies which are very volatile when ſeparate, are very fixed after their combination. We can never conjecture or eſtimate the ſpecific gravity of a compound from that of its component parts. The attraction of compoſition therefore changes all the properties of ſuch bodies as unite; and it is always by experiments ſubſequently made, and never by previous calculation, that we can determine the properties of the compounds.

14. The ſeventh law. *The attraction of compoſition is meaſured by the force required to ſeparate the component parts.* It is eaſy to conceive that any natural force can be eſtimated at its true value only, by that force which is neceſſary to deſtroy or render it ineffectual by oppoſition. Thus, it is, that we meaſure the weight of a body by ſuſpending it;

or, which is the ſame thing, by preventing its falling to the earth by a counterpoiſe which is in equilibrio with it. In this manner it is, that tenacity, or hardneſs, is aſcertained by meaſuring how much weight is required to break a tenacious or hard body. It is thus alſo, that the quantity of ſound and light is aſcertained by meaſuring the ſpace which oppoſes a reſiſtance to them during their paſſage, &c. But it is eſſential, however ſimple this explanation may appear, to arrange it among the laws of compoſition, becauſe erroneous ideas reſpecting the meaſure or determination of this force have frequently been given. By an attention too immediate to the firſt appearances, chemiſts have ſuppoſed that thoſe bodies which combine the moſt ſpeedily or with the greateſt quantity of motion, have the ſtrongeſt affinity for each other; with theſe chemiſts, the ſpeed of combination became the meaſure of affinity. It has been aſcertained, that this is a ſource of error and deluſion. It often happens on the contrary, that ſuch ſubſtances as are the moſt difficultly brought into combination, are thoſe which adhere the moſt ſtrongly to each other. Whence it reſults, that the true and only exact method of determining the force of chemical attraction between bodies, is to meaſure the force we are obliged to employ to ſeparate the conſtituent parts of a compound. The development of the following laws will render this ſtill clearer. It will be ſufficient to add, that the time neceſſary to form a combination cannot expreſs its force, and that the reſpective quantities of the ſubſtances capable of uniting, which ſome modern chemiſts have aſſumed as the ground of eſtimate in chemical attraction, though much better adapted to lead us to the deſired reſult, are ſtill too far from being known with ſufficient preciſion to be conſidered in the eſtabliſhment of a law reſpecting this force.

15. The eighth law. *Bodies have different degrees of attraction for each other, which are to be aſcertained by obſervation.* This is one of the ſimpleſt enunciations among the laws of attraction of compoſition, but it is, nevertheleſs, one of thoſe which leads to the moſt numerous and uſeful reſults in the accurate knowledge of this natural force. It has been long known that certain natural bodies refuſe every kind of union, while others, on the contrary, attract and combine with each other with the greateſt force. Though it may have even been ſeen, that this force has different degrees of power with regard to bodies which combine together: it is only ſince the commencement of the eighteenth century, that the relative affinities, or proportional adherence of bodies to each other, has began to be eſtimated with ſome portion of exactneſs. As the ſtudy of this eighth law is calculated to throw the greateſt light upon all the chemical phenomena, it is eſſential to examine the circumſtances with care.

When two bodies are united by the attraction of compoſition, if a third body be preſented, obſervation proves that this laſt is affected in four different manners. Either it remains without combining and produces no change of compoſition; or it unites to the compound, and forms a ternary compound: or it combines with one of the two principles of the firſt compound, with which it forms a new compound, and entirely ſeparates the other principle; or laſtly, it unites with a part only of one of the two principles of the compound of which it then only cauſes a change of proportion, and it forms with that part of the principle which it has ſeized, a new compound, different from that which it would have formed if it had entirely ſeparated it as in the third caſe.

The firſt caſe, ſuppoſes the abſence of attraction, or the moſt feeble attraction between the new body which is preſented to the two firſt principles in combination, as well as the combination which reſults. The equilibrium of the primitive compound ſubſiſts.

The ſecond caſe indicates an attraction of the third body, equal to that of the two firſt with their combination. The product is a ſurcompound.

The third caſe, announces a ſtronger attraction between the body added and one of the two which form the compound. The effect then is a decompoſition of the firſt compound, the formation of a new binary compound, and a ſeparation of one of the principles of the former.

Laſtly, in the fourth caſe, where there is a partial decompoſition, two new binary compounds ariſe which remain in equilibrio of compoſition.

17. In theſe two laſt caſes it is, that, with Bergmann, we muſt denominate the force which operates the decompoſition, elective attraction, becauſe this effect is the conſequence of an attraction, which, in a certain reſpect, is of the nature of choice between one of the two principles of the firſt compound, and the third body which is added.

18. In the third caſe of elective attraction as well as in the fourth, it commonly happens that the body, ſeparated in the midſt of the liquid ceaſing to remain diſſolved, is depoſited in the form of powder, or very ſmall polygonal figures. In this caſe, a precipitation is ſaid to take place. The ſubſtance, employed to produce this effect, is called the precipitant, and the depoſition which is afforded, is called the precipitate.

The precipitate is diſtinguiſhed into *pure* and *impure*. The firſt muſt be well aſcertained to be the ſeparated body itſelf, for example, a metal with all its brilliancy and peculiar ſplendour; the ſecond, has properties very different from thoſe of the body itſelf which ought to be ſeparated, and ſhews that it is in a new ſtate of combination, ſo that the effect is not then a ſingle or ſimple decompoſition, but conſiſts of the ſeveral complicated effects. *True* precipitates and *falſe* precipitates have alſo been diſtinguiſhed; the firſt formed by the ſubſtance ſeparated, and the others by the new compounds which, in that caſe, are leſs ſoluble than the body ſeparated. But, in order to ſhow the abuſe of theſe denominations, it is neceſſary to remark, that when the action of a ſimple elective attraction takes place, ſuch as is here ſpoken of, namely, when a compound of two bodies, diſſolved in water, is decompoſed by means of a different attraction by a third body, alſo diſſolved in water, one or the other of the following phenomena comes to paſs.

Either the ſeparated matter being inſoluble and the new compound ſoluble, this laſt remains in the fluid, and the ſeparated body is precipitated; *pure*, if it be alone, or *impure*, if it carry with it a portion of the new compound; which moſt frequently happens; or otherwiſe the new compound being ſoluble, and the ſeparated body alſo ſoluble, the fluid remains clear without precipitation, and the decompoſition cannot be aſcertained but by the ſubſequent examination of theſe mixed liquors; or laſtly, the new compound thus formed being inſoluble, and the body ſeparated, being, on the contrary, ſoluble, this laſt remains in ſolution in the fluid, and the compound which ſeparates is that which has been called a falſe precipitate. Whence we ſee that there is a radical vice of nomenclature, ſince the ſame ſubſtance has been called a precipitate, whether it was the ſeparated matter or the new combination. Accordingly, therefore, we do not now uſe the expreſſion of precipitate which was formerly much employed, unleſs to repreſent the phenomenon, and by no means to determine the nature of the ſubſtance which is formed.

19. We ſhall ſtill more clearly perceive the uncertainty, and even inconvenience, as well as the falſity of this term of precipitate, when, it is obſerved, that the matter which is ſeparated from a binary compound, by a third which decompoſes it, by ſeizing one of its two component parts, inſtead of being depoſited or falling down to the bottom of the fluid, riſes in vapour, and becomes volatilized, when it is ſuſceptible of this effect, and when there is enough of heat extricated to evaporate it; and alſo when we ſhall ſee that this expreſſion of precipitate, which is applied to bodies, and to phenomena ſo very different from each other, cannot be uſed except with regard to operations performed in the *humid way*. It can ſcarcely ever be applied to experiments made in the *dry way*, becauſe the phenomena, relative to precipitation, are ſcarcely ever ſeen in this laſt method in a manner which can be appreciated.

The terms humid way are applied, in chemiſtry, to all the operations which take place with liquid bodies, which muſt likewiſe be tranſparent in order to render the phenomena of precipitation ſenſible; and the words, dry way, are applied to all the proceſſes which are made with dry pulverulent bodies, not liquefied by moiſture but by the action of heat.

20. There are a great number of caſes of elective attraction, in which a compound of two bodies, which undergoes no alteration on the part of a third, or a fourth body, each being ſuppoſed to be ſingly preſented, is, nevertheleſs, decompoſed when this third and fourth body are preſented both at once, or previouſly combined. This caſe is called double elective attraction, by way of oppoſition to the ſimple elective attractions previouſly diſcuſſed in the numbers from 16 to 19. Though this ſpecies of elective attraction has been long conſidered as very difficult to comprehend and explain, it will be eaſily conceived, if attention be paid to the union of the two forces which conſpire, in ſome reſpect, to deſtroy the compound; and which prevail when united to cauſe the change by their ſum which exceeds the ſum of the attractions, by virtue of which the ſubſtances forming the firſt compound adhere. Let us ſuppoſe by way of elucidation, a compound AB. of which the firſt principle A. adheres to the ſecond principle B. with a force meaſured by the number 8; add to this binary compound a third body C. which has for A. or for B. an attraction equal to 6. It is evident, that this body C. will produce no effect upon the compound

pound AB. of which the force of compoſition is repreſented by 8; a greater number than 6. In the ſame manner, let another fourth body D. be preſented ſingly, and by itſelf, to the compound AB. of which the attraction for its principles B. or A. is equal to 7. This new body will likewiſe have no power in changing the compound AB. But, ſuppoſe the two bodies C. and D. to act at the ſame time upon the compound AB. the body C. then attracting the principle A. with a force equal to 6, and the D attracting the principle B. with a force equal to 7, the ſum of theſe two forces united give 13, which, being much greater than 8, will effect the decompoſition. This then is the whole myſtery of double elective attraction.

21. We muſt not confound with the double elective attraction, as has been done by many of the moſt ſkilful chemiſts, thoſe numerous caſes in which, by placing in contact with a binary compound, another binary compound, of which one of the principles alone would have been ſufficient to deſtroy the firſt combination; a double decompoſition and recompoſition takes place. For the ſecond principle of the ſecond compound was not neceſſary, in this caſe, to deſtroy the firſt compound. In order to diſtinguiſh with accuracy theſe caſes, from thoſe of the true double elective attractions, in which the application of two bodies is required for the decompoſition of a compound, I name theſe attractions which are exerciſed under the firſt

circumſtances, *ſuperfluous* elective attractions, and thoſe which take place in the ſecond, *neceſſary* elective attractions, after the manner of Linnæus in his Polygamia Syngeneſia.

22. To explain, with ſtill more perſpicuity, the effect of the elective attractions, it is uſeful to denote with Mr. Kirwan thoſe attractions by the name of quieſcent, which tend to leave the compounds in equilibrium and repoſe, when there is no decompoſition in the mixtures; and thoſe by the name of divellent attractions, which operate the decompoſition of compounds; becauſe they tear aſunder, as it were, the principles from their firſt union. Thus we may affirm, that when a decompoſition of a compound, by one or more bodies which are added, takes place, whether in the caſe of ſimple elective attraction or double elective attraction, the divellent attraction in the firſt caſe, or the ſum of the divellent attractions in the ſecond, are greater than the ſum of the quieſcent attractions.

23. It would be of great utility if we could accurately determine the force of the elective attractions which exiſts between all natural bodies. By attempting to do this by numbers, as I have done fifteen years ago, I have given only a method of approximation which may be admitted to be arbitrary as long as we have no accurate foundations on which we can eſtabliſh, or according to which we can calculate, the preciſe value of theſe forces. We are ſtill far from having grounds to hope for ſuch a baſis; we

do not yet ſee even conjecturally the methods which ſhould be followed for their diſcovery. We are, therefore, content to expreſs, by their nearer or more remote poſition, thoſe bodies of which we are deſirous of exhibiting the elective attractions, by placing the bodies in the order of the reſpective force of attraction. It is the ſimple repreſentation of the reſpective ranks, and not the preciſe degree, or real and proportional value of attraction, which is deſignated in the tables of affinity or chemical attractions.

24. It is highly uſeful for the ſtudy of the ſcience, and to direct the ſubſequent reſearches of chemiſts, not only to exhibit, in this manner in tables, the rank which bodies hold in their relative attractions, and to increaſe the number of their columns as chemiſts daily do,—but it is equally advantageous to repreſent by this kind of formulary, after the example of Bergmann, the effects of double or ſimple elective attractions, in order to know at one glance of the eye, all that happens in the mixtures and contacts of the different compounds with matters not decompoſed or with other compounds. We may even by the mere relative diſpoſition of compounds and their principles, exhibit to the eye the ſenſible effects of ſolution, precipitation, decompoſition, recompoſition, volatilization, &c. which take place during the ſimultaneous action of all ſimple or compound bodies which are placed in contact.

25. Ninth law. *The attraction of compoſition follows the inverted ratio of the ſaturation of bodies by each other.* In order to give a clear conception of this law or conſtant phenomenon, which is more abſtracted, and more difficult to be comprehended than the preceding laws, we muſt firſt obſerve that bodies, when they combine together by the attraction of compoſition, do not unite but in proportions eſtabliſhed by nature; that when they have arrived at this relative proportion of compounds, they are incapable of combining with any greater quantity of each of their component parts; and this point ſo attained is denominated ſaturation. It muſt be obſerved, in the ſecond place, that moſt bodies capable of combining, and which conſequently tend to unite in a given proportion, do not arrive at a complete ſaturation, but under a favorable conjunction of circumſtances; that when theſe circumſtances do not exiſt, the union between them, though not ſatisfied, becauſe ſaturation has not yet taken place, remains nevertheleſs in equilibrium, or in a ſtate of repoſe, till the coincidence of ſuch circumſtances; and that conſequently we ought to diſtinguiſh the combinations of the ſame bodies in different quantities, and, as it were, different terms from the minimum to the maximum. Now it is at theſe various terms, which may be more or leſs multiplied, that the conſtant phenomenon here noticed, or the exiſtence of the law concerning which I treat at preſent, is

obſerved, namely, that the firſt portion of a body, which unites to another body, adheres more ſtrongly than the ſecond, that the ſecond adheres more ſtrongly than the third, and, laſtly, that the attraction is ſo much the more feeble as it approaches the more towards ſaturation. This fact agrees with another obſervation equally important, namely, that, in general, the more ſtrong the attraction of any body, for another body, the leſs is the quantity it will require for its ſaturation; whence it alſo happens, that, by decompoſing a ſaturated compound, the laſt portion is expelled more eaſily than the firſt, which it retains more ſtrongly.

26. The tenth law. *Decompoſition may take place between two compounds, which do not mutually decompoſe each other by double elective attraction,—if the attraction of two of the principles for a third, be ſtronger than that which unites this third to one of the two firſt, though, at the very moment, the act of union between thoſe two firſt principles does not yet exiſt.* We may ſuppoſe, at firſt ſight, that this law is, in effect, a caſe of neceſſary double elective attraction, but we ſhall, on examination, find that it is a very different effect from what is repreſented and explained in thoſe inſtances. In the preſent caſe, we conſider an attraction which exiſts between a binary compound not yet formed, and another body which is united to a fourth. So that this attraction, which I call *pre-diſpoſing*, is the only cauſe which operates

the formation of this compound, and the decompoſition of another compound, which would not have taken place without the formation of the firſt. It is, indeed, a different thing, and ſomething more in effect than the caſe of double elective attraction. In order to form a proper notion of this diſpoſing attraction, let us ſuppoſe a compound N. O. and another compound P. Q. of which the four component parts N and P;—O and Q. have not for each other an attraction which exceeds in its force that which holds them united in N. O. and P. Q. It is evident that there cannot, in this caſe, be any decompoſition by the neceſſary double elective attractions, becauſe the quieſcent attractions are ſtronger than the divellent. Nevertheleſs, if the force which tends to unite O. and P. together, added to that which tends to unite the compound O. P. and Q. be more conſiderable than that which at the firſt moment keeps N.O. and P. Q. in union, there will be a decompoſition by the formation of a ternary compound O. P. Q. and a ſeparation of the firſt component part N. And this will not be a true double elective attraction, becauſe there is not a mutual and inverſe union of the two compoponent parts of each compound, in ſuch a manner as to form two new binary compounds; and becauſe the product of this double-diſpoſing elective attraction is on the one part, the formation of a ternary compound, and on the other the diſengagement of one of the component parts, which is not the character of a double elective attraction.

27. All the caſes of attraction which have been detailed in the development of the ten laws here exhibited, take place, in general, between two, three, or four bodies; and the effects may be very well calculated by the rules which have here been laid down. But theſe effects are much more complicated, if more than four bodies be placed in contact, or if they exerciſe mutual attractions ſtill more numerous. For example, when ſeveral ternary or quaternary compounds, or compounds ſtill more complicated, re-act upon each other, the action of a great number of different principles taking place, each on the other reſpectively, one upon one, two upon two, or three upon three, the calculation of the effects which muſt happen, containing a much greater number of elements, muſt alſo afford reſults on the whole more different and more numerous. This is what happens in ſeveral caſes, which the ſcience of chemiſtry cannot yet, without difficulty, explain, and which depend on the complicated elective attractions; this is more particularly obſervable in the multiplied chemical attractions which vegetable or animal matters exert upon each other, during the proceſs of life in vegetables, and animals.

28. It is only by the obſervation of the phenomena, and conſequently by a ſeries of experiments that we can give an account of the

effects of the attraction of compoſition. As we are abſolutely unacquainted with the ſenſible and menſurable properties of the conſtituent particles between which this force is exerted;—as we poſſeſs no means of eſtimating their volume, their form, their ſurfaces, their relative weight, their diſtance, or to compare them together in the different ſimple or undecompoſed bodies, of which they conſtitute the texture, as well as their various nature, we cannot determine previouſly, or before the obſervation of their mutual effects, the mode of action which they may exerciſe with reſpect to each other, or the kind of attraction which may exiſt between them. It is impoſſible to ſubmit to the preciſion and accuracy of computation, that which muſt reſult from their various and multiplied unions. We are not yet informed whether there be not a repulſion between ſome of thoſe principles; and though ſeveral philoſophers have been obliged to admit this oppoſite force, by making uſe of it in a certain reſpect as a counterpoiſe to attraction, in order to explain various natural phenomena, and among others, thoſe of electricity and magnetiſm, it has not yet been thought neceſſary to apply it as a principle in chemiſtry, in which philoſophers have been contented to obſerve and deſcribe the reſults with accuracy. This operation of nature which preſides over chemical attractions, is in its effects, concealed under the impenetrable veil of the minuteneſs of the particles between which it is exerciſed.

29. Hence we may deduce, that all the theories which have been offered to explain the elective attractions, and the cauſe of combination, are hypotheſes of more or leſs ingenuity. And it is not permitted us to give any preference to one of theſe beyond the others, until ſome happy diſcovery, no doubt very remote from thoſe of which we are now in poſſeſſion, ſhall lead chemiſts to a greater advance than they have been able to make in the courſe of truth. Whether this force be owing to the form of the conſtituent particles, to their diſtance, or merely to their reſpective weight;—whether it be the ſame as the general attraction, modified ſimply by the form of the particles between which it takes place, or whether we ought to admit it as a power abſolutely different, and to maintain that it differs from general attraction by the laws to which it is ſubjected,—Theſe objects of inveſtigation, as well as all thoſe we might propoſe in the actual ſtate of the ſcience, have no other foundation than in the imagination; they are merely hypothetical. Though it does not become us abſolutely to reject any of theſe inductions which may be preſented upon a ſubject ſo difficult, in a path where it is ſo eaſy for the mind to be miſled, it is, nevertheleſs, much more wiſe and uſeful to continue to interrogate nature without ceaſing, to multiply experiments and inquiries, as is the practice

of chemiſts, and to wait for the anſwers of this power, reſpecting the ſolution of a number of problems, which the ſtudy of ſimple and double, prediſpoſing, and more eſpecially the complex or complicated elective attractions preſent to our view.

30. From this method of proceeding, from experiment alone it is that we have already received ſo much of elucidation, reſpecting the pretended anomalies in the attractions. By the name of anomalies, we deſignate effects which are varied and apparently contradictory to the laws which preſent themſelves in the ſame bodies in their union and diſengagement. It has been ſhown by multiplied experiments, that theſe anomalies are only apparent, and depend upon the various circumſtances which accompany the operation of chemical attractions, and of which proper notice had not been taken at the time when theſe pretended variations in the relative attractions had been admitted. Obſervation, ever faithful to thoſe who employ it, has never failed to reduce again into the claſs of errors, numerous diſtinctions of the affinities which were deduced only from theſe deluſive variations. It teaches us at preſent that we do not admit of anomalies, unleſs for want of having actually obſerved all that takes place in the attractions; and that when theſe anomalies are admitted to exiſt in ſome operations of chemiſtry, the cauſe of ſuch a concluſion is, that we have not yet exactly determined all the circumſtances

cumſtances of our operations. It ſhows that the liquid or ſolid ſtate of the bodies, the preparations made uſe of, the relative quantity of water in which they are ſuſpended or diſſolved, the quantity of caloric which ſeparates them, or the maſs of heat to which they are expoſed, the degree of cooling to which they are ſubjected, the fantaſtic or imaginary properties which have ſo often been feigned in the ſtudy of nature,—and, in addition to all this, the levity, the rapidity, and careleſsneſs with which experiments have been made; the too ſpeedy concluſions which have been deduced, the circumſtances which have not been properly noticed, are the true ſources of thoſe anomalies which have been affirmed to exiſt, and that theſe anomalies diſappear when the facts are conſidered in every point of view; the number of ſuch irregularities being always diminiſhed in proportion as we advance in the accurate knowledge of the phenomena of nature.

ARTICLE IX.

Concerning the Chemical Phenomena of Nature and the Arts.

1. AS all the details of the preceding article have proved that the force of attraction, by which compounds are formed, is placed by nature in every individual body with a certain

determinate degree of power, it is evident, that the phenomena, produced by this force muſt take place in all the ſcenes which paſs in the world, and of which the totality conſtitutes the harmony of the univerſe.

2. As theſe phenomena are of two claſſes, with relation to the maſs of bodies in which they originate or between which they are exerciſed; namely, between large bodies, conſtituting the forces which govern the motions and the relative diſtances of the planetary bodies, or elſe between the particles of each body ſingly conſidered;—and as, on the other hand, the attraction of compoſition never acts but upon the latter, it is manifeſt that the effects which take place among the particles themſelves are alone entitled to be conſidered as chemical phenomena. But it is not the leſs neceſſary on this account that the chemiſt ſhould ſtudy the reſults, and thence explain the mechaniſm or theory of this force.

3. The number of natural effects which appertain to the attraction of compoſition, and are alone to be explained by philoſophical chemiſtry, muſt be immenſe and unlimited. Nature, indeed, holds in her diſpoſition every poſſible compound matter in all its ſtates, and her operations are not bounded like thoſe of man, in the narrow limits either of ſpace or time. Theſe elements of her power and her forces are combined in thouſands of forms, and

the reſults conſiſt in a numberleſs ſucceſſion of effects.

4. We may, nevertheleſs, in order to acquire a general idea, limit theſe effects to a certain number of claſſes, or confine them to a certain number of leading operations which, without entering into details, will embrace the generality and circumſcribe the whole. I have already attempted to do this in my "Philoſophy of Chemiſtry," by including, in a methodical outline, every thing that appertains to the general theories of chemiſtry as a natural ſcience.

5. By following a courſe, if not the ſame, at leaſt ſimilar to what is there deſcribed, I ſhall obſerve, that we may include under four general titles all the natural phenomena of chemiſtry which take place on the terreſtrial globe.

6. The firſt title comprehends thoſe which are preſented in the atmoſphere under the form of meteors, and which belong to that branch of ſcience which I have deſignated by the name of meteoric. They relate to the hygrometrical, thermometrical, and barometrical ſtates of the air, to rain, dew, miſts, ſnow, hail, lightning, thunder, and in general all the meteors.

7. Under the ſecond title I place thoſe chemical phenomena which take place between foſſils. They are the ſubject of mineral chemiſtry, and include the entire formation and ſlow decompoſition of earths, ſtones, ores, bitumens, mineral waters, the ſpontaneous altera-

tion of metallic ores, of earthy and ſtony depoſitions, the tranſpoſitions of foſſil matters, ſolutions, cryſtallizations, ſtalactites, ſubterraneous ſtrata, the forming and ſucceſſive change of mountains, vallies, plains, ſaline and metallic efflореſcences, volcanic inflammations, and products, and all that belongs to mineralogy and geology, conſidered with regard to the chemical compoſition of foſſils.

8. To the third title of natural chemical phenomena, belongs every thing that relates to the life and death of vegetables. Vegetable chemiſtry is its ſubject. Theſe phenomena include the germination, the influence of various earths, the foliation, the formation of wood, the fall of the leaf, the fading of flowers, fecundation, the maturation of fruits and ſeeds, the nutrition of plants, aſcent of the ſap; influence of the air, of water, of heat, of ſolar light, of ſhade, and the various atmoſpheres upon vegetation, the nature of the gaſes which vegetables exhale, the compoſition of their common and proper juices, and their different materials; the natural alteration of theſe juices, their changes and ſucceſſive tranſitions, the deſtruction of lifeleſs vegetables in water, in air, in the earth, the formation of bitumens, and, in general, every thing which can enlighten the philoſophy of vegetables.

9. Laſtly, under the fourth title, I include thoſe natural chemical phenomena which take place in animal matters during and after the ter-

mination of the life of animals, and which are ſtill more multiplied than thoſe of the preceding title. They form the matter, or they are the reſult of animal chemiſtry.—Such are the changes of vegetable and animal ſubſtances by their digeſtion and nutrition, the effects of reſpiration, the nature of the conſecutive alterations of the fluids, their converſion into ſolids, the qualities of irritation, motion, and perhaps even of ſenſation in theſe laſt; the formation of muſcles, bones, and membranes, the functions of the liver, the kidnies, &c. the ſecretions conſidered as to their quantity and qualities; every ſecreted fluid, and every ſolid when in a diſeaſed ſtate, or changed by morbific affections; the effects of remedies and of poiſons on the fluids and organs of animals, the means of oppoſing theſe effects, and deſtroying or correcting them, the progreſs of ſlow deſtruction in lifeleſs animal matter or putrefaction; and the compariſon of moſt of the preceding phenomena, with thoſe which take place in vegetable ſubſtances.

10. All the important conſiderations comprehended under the four preceding titles, are indicated in the different ſections of this work, to which each of them are referrible. I have, in this place, only taken a ſlight general view of their exiſtence, as effects of chemical phenomena produced by nature, and of which the ſtudy ought to accompany chemical experiments. I have preſented them only as a ſketch of that

chemical plan which nature herſelf ſeems to have traced out, and as the knowledge which the chemiſt ought to endeavour to acquire.

11. As the arts are moſt commonly imitations of the operations of nature, or means of obtaining at pleaſure, and in a conſtant manner as well as in the ſhorteſt poſſible time, ſuch products as are appropriated to our various wants, by modifying, in a manner conformable to our uſes, the ſeveral objects which the globe preſents to obſervation on its ſurface and in its interior; it will be ſufficient that we ſhould conſider their totality, in order to form a right conception of them, in two great claſſes. Some of thoſe arts, in fact, change only their form and the exterior or perceptible properties of bodies; theſe are the mechanical or geometrical arts; the others modify their intimate compoſition, and cauſe them to undergo changes or alterations which are the ſubject of chemical ſcience.

12. The chemical arts being nothing elſe but alterations or changes produced in bodies by the attraction of compoſition, it follows that we may conſider them as true chemical proceſſes executed in the large way, ſo as to obtain conſtant products with the leaſt expence and conſumption of time poſſible.—Chemiſtry, therefore, comprehends the whole of thoſe arts in its manipulations, and poſſeſſes the office of enlightening, correcting, improving, or extending

tending them, and even of creating new arts in proportion as its own progreſs ſhall become more advanced. We may affirm, that there is not any ſingle operation among its proceſſes, nor a ſingle diſcovery of this ſcience, which may not be conſidered as the ſource of a new art, or of new advances to be made in ſome art already eſtabliſhed.

ARTICLE X.

Concerning the principal Operations of Chemiſtry in general.

1. THE chemiſt cannot obtain the reſults of which he is in ſearch,—he cannot acquire a knowledge of the nature, the compoſition, and the re-action of bodies upon each other, without bringing them in contact, diſpoſing them to unite, or, in a word, by placing them in the moſt favourable ſituation for the energy of the attraction of compoſition, by means of which they mutually act upon each other. All thoſe methods which are of the nature of analyſis or ſyntheſis, demand certain manipulations, certain proceſſes which are called chemical operations, which we do not here propoſe to deſcribe, but merely to compare, in order to render the uſe and application of them more eaſily underſtood in the ſeveral parts of this work, where mention ſhall be made of them, without its

being neceſſary to deſcribe minutely the manual part, which is foreign to this treatiſe.

2. Beſides the preliminary operations which were formerly denominated ancillary, or preparatory, and which conſiſt in dividing, ſeparating, and purifying theſe bodies which are propoſed to be afterwards treated by the chemical methods, ſuch as pulverization, levigation, filtration, purification,—the chemical art comprehends a great number of other manipulations which have particular objects and denominations. We ſhall proceed to define them in ſucceſſion, and give a general notion which will be ſufficient to explain their uſe and application.

3. *Fuſion* is that proceſs by which we ſoften, or melt, or render fluid by means of fire, thoſe ſolid bodies which are capable of being ſo treated; ſuch as the metals, ſulphur, phoſphorus, fats, wax, many ſaline matters, &c. We uſe the term, to fuſe bodies, or to bring them into a ſtate of fuſion.

4. *Eliquation*, or liquation, though a real fuſion denotes an operation upon compounds more eſpecially metallic alloys, of which one or more of the component parts becoming fluid, or ſoftened by heat, are ſeparated in this manner from the others. It is a metallurgic operation.

5. *Volatilization* is the name of that proceſs by which certain ſubſtances, capable of a ſtate of vapour, are made to fly off or become vola-

tilized by the action of fire as the term denotes.

6. *Sublimation* conſiſts in the particular volatilization, or elevation in vapour, and condenſation in the upper part of the apparatus, of ſubſtances in the dry and ſolid ſtate.

7. *Evaporation* is practiſed when a liquid or fluid is reduced to vapour in the open air, in order to bring the fixed matters which were diſſolved therein into a denſer ſtate, and to obtain them dry and ſeparate from the fluid.

8. *Precipitation* is the ſeparation, in a dry and pulverulent form, of any ſubſtance whatever, diſſolved in a fluid, from which it is cauſed to fall in a ſtate more or leſs inſoluble by a chemical decompoſition, as has been obſerved under the article attraction of compoſition.

9. *Cryſtallization* comprehends the art of cauſing bodies after fuſion or ſolution, to aſſume a regular polyhedric and cryſtalline form, which characterizes them, by depriving them of the ſubſtance which before held them in a fluid ſtate. By the word cryſtallization, we frequently denote the form itſelf of the cryſtals.

10. *Stratification* is the practice by which bodies are expoſed to their mutual action by arranging them in veſſels layer by layer, ſtrata ſuper ſtrata, as it is uſed in the metallurgic art.

11. *Cementation* is a kind of ſtratification, the object of which is to cauſe a portion of the cement, which is a powder enveloping all the

parts of the body propoſed to be cemented, to re-act upon this body. It is ſcarcely uſed excepting in ſome metallic proceſſes.

12. Diſſolution, or more frequently ſolution, takes place whenever a ſolid becomes fuſed in a liquid, and partakes of its liquidity. Some chemiſts have been deſirous of diſtinguiſhing diſſolution from ſolution, but theſe two words ſignify at preſent the ſame thing, and are only applicable to the ſimple liquefaction of a ſolid in a fluid, without any real change in either of thoſe bodies. When this change happens, though the word ſolution is in this caſe often employed, the deſcription or indication of the accompanying phenomenon is uſually made; an effervescence is commonly mentioned.

13. *Efferveſcence* is that phenomenon, rather than the operation, by which elaſtic fluids are diſengaged from the interior of a liquid; the bubbles of which paſſing through the liquid, agitate them, cauſing it to riſe up, and cover it with a froth or ſcum.

14. *Concentration* conſiſts in condenſing by the evaporating action of fire, ſaline or other fluids, in order to render their ſolution more denſe, and, in a word, more active.

15. *Graduation* is a proceſs, the object of which is to bring by evaporation or concentration, fluids to a degree of conſiſtence or denſity neceſſary to ſeparate more eaſily and ſpeedily the ſubſtances they hold in ſolution. It is more particularly uſed with ſalt waters.

16. *Infuſion* is practiſed by ſuffering any ſubject, particularly vegetable matter, to remain for a time in hot water poured upon it. Any other hot liquid may be applied in the ſame manner. In this manner the beverage called tea is made. It is improperly that the fluid itſelf, thus produced, is called an infuſion. We ought to denote it by a term (*infuſé*) derived from the Latin *infuſum*.

17. *Maceration* is that proceſs which takes place by ſuffering bodies to remain a certain time in a liquid.

18. *Digeſtion* is a maceration in cloſed veſſels, effected by expoſing the liquid, intended to act upon the ſolids, to a gentle heat, continued for ſome time. This name has been given to it becauſe it has been compared to the digeſtion of food, which was thought to be effected by a ſimilar proceſs in the ſtomach.

19. *Decoction* takes place when a liquid is boiled with a ſubſtance upon which it is intended to act. This word is alſo uſed to denote the prepared fluid, whereas we ought to uſe another term, derived from the Latin decoctum.

20. *Extraction* is the operation by which one ſubſtance in general is extracted from another.

21. The word *inſolation* has been ſometimes uſed to denote that expoſure to the ſun which is made with the intention of favouring, by

the contact of its rays, ſome action between bodies.

22. *Diſtillation* is an operation by which compound ſubſtances are ſubmitted to heat, in cloſed veſſels, in order to collect and condenſe the volatile parts. The bodies thus become ſeparated into volatile principles and fixed principles. Its object is alſo to decompoſe complex combinations, to change their nature by converting them into ſeveral other leſs compounds. In the firſt caſe, its effect conſiſts in the true analyſis, and, in the ſecond, in the falſe analyſis.

23. *Cohobation* is a kind of diſtillation, in which the liquid product is cauſed to paſs a number of ſucceſſive times upon the reſidue from which it was expelled, or upon a new quantity ſimilar to that of the firſt diſtillation.

24. *Rectification* is a ſpecies of diſtillation, by which fluids are purified in ſome inſtances, by ſeparating them from the more volatile parts which change their qualities, and ſometimes by volatilizing the ſubject itſelf, in order to ſeparate it from the fixed matters which diminiſhed its purity.

25. *Torrefaction*, or roaſting, conſiſts in the ſeparation of ſome of the volatile principles of a dry ſubſtance, and the diviſion or attenuation which it undergoes at the ſame time. Such are the changes which ores are made to undergo before their fuſion. It is to this laſt operation

that the term roaſting is applied; the word Torrefaction is frequently uſed to denote the application of fire to vegetable ſubſtances.

26. *Calcination* is uſually the volatilization of ſome matter in vapour, or in gas, and by this, means its ſeparation from another more fixed ſubſtance, which is ſaid to be calcined.

27. *Cupellation* is applied to the ſeparation of the very oxidable metals from thoſe which are very little oxidable. The ſmall cups, or cupels, of calcined bones, which are uſed to abſorb the lead in the form of a vitrified oxide, when it ſeparates from gold or ſilver, have given the name to this operation. It is not uſed but in the act of aſſaying and refining metals.

28. *Vitrification* is the fuſion of matters, ſuſceptible of aſſuming the brilliancy, the tranſparency, and the hardneſs of glaſs.

29. *Lixiviation* is a maceration joined to filtration. An example of this is ſeen in the making of lie from wood-aſhes in domeſtic uſe.

30. *Deſiccation* conſiſts, as its name implies, in drying ſoft humid matters, and in depriving them of the water which they contain, which would cauſe them to undergo a ſpontaneous change. It is practiſed by expoſure to the ſun, or in a ſtove, or on a ſand-bath, and it is uſed with vegetable and animal matters, ſalts, earths, and the metallic oxides when in a moiſt ſtate.

31. Though the word *combuſtion* is moſt frequently taken to expreſs the phenomenon itſelf, it is ſometimes applied to the operation of burning different combuſtible bodies. I frequently uſe the word *de-combuſtion* to deſignate the inverſe operation of this firſt. I alſo, in this ſenſe, uſe the term to unburn bodies.

32. The word *inflammation* is more frequently, and ſtill more clearly, applied in a practical ſenſe; becauſe the phenomenon itſelf is the aim of the operation, namely, that of putting the ſubſtance itſelf into a ſtate of flame or inflammation.

33. *Detonation* takes place in all caſes where ſubſtances, being combined or decompoſed very rapidly, change all at once their ſtate, and inſtantly occupy a greater volume, and by means of this ſudden extenſion, ſtrike the air, ſo as to occaſion a greater or leſs ſound by its vibration.

34. *Fulmination* does not differ from detonation, excepting by the greater rapidity of the ſtroke, the more violent noiſe and the greater reſemblance of the ſound to thunder, from which it has taken its characteriſtic name.

35. *Incineration* is a kind of combuſtion carried into effect upon reſidual coals, by cauſing them to become red-hot with the contact of the air, and frequently renewing their ſurfaces by agitation, or ſtirring until they are reduced to aſhes.

36. *Oxidation* is a term applied to every operation by which any ſubſtance is combined with oxigen, ſo as to become converted into an oxide. This word is moſt frequently employed to expreſs the phenomenon rather than the operation. In this laſt ſenſe, we may alſo uſe the oppoſite word diſ-oxidation, which then denotes an operation no leſs frequently performed in laboratories than the former.

37. *Reduction* is the proceſs by which the oxides of metals are cauſed to appear again under the metallic form. It is alſo called a revivification, and is truly a diſ-oxidation.

38. The term *fermentation* is moſt frequently uſed to denote the phenomenon by which vegetables and animal ſubſtances undergo a peculiar change, but it is alſo ſometimes uſed to expreſs the operation by means of which chemiſts cauſe thoſe ſubſtances to ferment.

39. The thirty-eight different kinds of operations, of which ſhort definitions are here given, comprehend every thing which can be done, or in effect performed, in the laboratories and experiments of chemiſtry. The object, the effect, and the uſes are here exhibited in a ſhort outline. The proceſſes themſelves could not be deſcribed but in a work conſecrated to the practical part of the ſcience. We ſhall, however, give a preliminary notion, or ſhort deſcription, of theſe proceſſes in ſome parts of this work, though they are particularly appropriated to the theory of chemiſtry.

ARTICLE XI.

Concerning the Chemical Claſſification of Bodies.

1. FROM the explanations detailed in many of the preceding articles, it follows, that, by means of the natural power of the elective attraction employed by chemiſts in their operations, they have ſucceeded in proving that all bodies are either decompoſable or indecompoſable; that theſe laſt may be conſidered as ſimple, becauſe their habitudes are ſuch in all our experiments, and that the former ought to be regarded as compounds; that we do not know, and probably never ſhall acquire, a knowledge of the firſt principles of bodies; that all the opinions adopted in this reſpect are purely vain metaphyſical ſpeculations, of no uſe to the progreſs of ſcience; and that it is neceſſary to confine ourſelves on this point to the ſimple reſults of analyſis, to the agreement and real difference of the products they afford.

2. All the productions of nature, of which chemiſtry can acquire a knowledge, and reſpecting the compoſition, or the ſimplicity of which it is authorized to pronounce, may differ, and be divided into two great claſſes, the one of bodies ſimple or undecompoſed, the other of bodies compoſed or decompoſable. Whence the general data of all the operations of chemiſts

have led them to admit, among bodies, ſeveral diſtinctions very different from thoſe adopted in the other phyſical ſciences, and particularly in natural hiſtory. For chemiſtry being in poſſeſſion of another method, and different inſtruments to interrogate nature, it muſt receive other ſolutions, and will not confine itſelf to obſerve and claſs its productions from their phyſical and ſenſible properties, namely, their quantities, their maſſes, their volume, and their viſible external characters, as it is neceſſary to do in the ſtudy of natural hiſtory, which conſiders bodies in their relation of form, ſurface, place or habitation, different ſtates, periodical changes, regular or determinate alterations, in order to aſcertain what they are, to compare them with each other, and methodically to arrange them.

3. It is, no doubt, of great advantage in the methods of natural hiſtory, to divide all the products of the globe into three great claſſes—minerals, vegetables, and animals; to eſtabliſh for each of theſe claſſes the ſame number of kingdoms of nature, namely, the mineral, the vegetable, and the animal kingdoms. But this diviſion has the inconvenience of not including either light, or heat, or atmoſpheric air, which might, nevertheleſs, by their maſs and by their vaſt influence, form a fourth kingdom, modifying, enveloping, and even governing the operations of the three others. It alſo excludes the ſtrata of organized bodies in the

foſſil form, which are added to the minerals that conſtitute the globe, properly ſpeaking. While chemiſtry, ſo long uncertain reſpecting the comparative nature of theſe great claſſes of bodies, could offer no general conſiderations reſpecting their arrangement, it was under the neceſſity of following the traces of natural hiſtory, to purſue its courſe with fidelity, and to admit of the ſame claſſifications. No deviation could be permitted, under theſe circumſtances, or, if we may uſe the metaphorical expreſſion, chemiſtry could not yet take her flight, ſupported by her own ſtrength, or wander without a guide in the wide field of ſcientific reſearch.

4. But the numberleſs diſcoveries with which this ſcience has been enriched during the laſt thirty years, the preciſe notions which it has acquired reſpecting the nature of bodies, the clearneſs and certainty of its new reſults, the happy revolutions which, following in ſome reſpect that of the other ſciences, behind which it has long been placed, has, all at once, placed chemiſtry before thoſe branches of human knowledge, and has, as it were, charged this ſcience with the taſk of enlightening and directing their progreſs, demand, at preſent, a great change of its method, and allow it to create one different from thoſe which are followed in natural hiſtory and philoſophy; a method not only peculiar to itſelf, but calculated to render its progreſs more certain, and

its ſtudy more eaſy by the ſyſtematical connection of the facts upon which it is eſtabliſhed.

5. Since natural bodies, as well as the products of art, muſt be alike comprehended in this chemical claſſification; and, as this claſſification muſt be originally founded on the ſimple or compounded nature of theſe bodies, I include them all in eight grand diviſions, of which each, forming a peculiar claſs of chemical bodies, will appertain to one of the ſections of the following work from the ſecond to the eighth incluſively. The ſeries of theſe eight claſſes of chemical bodies is ſo diſpoſed or coordained in this new method, that it leads from the ſimple or leſs compounded bodies to thoſe which are more compounded; ſo that the properties or ſuſceptibilities of change in thoſe bodies, becoming multiplied, in proportion as we advance in their ſtudy, we ſhall find a greater number of means and inſtruments to appreciate and form a proper conception of them, in the knowledge acquired reſpecting thoſe which have preceded.

6. The firſt claſs of chemical bodies comprehends thoſe which have not by any art been decompoſed, which nature preſents either ſeparate or united together, but which art conſtantly finds unalterable and unchanged after its analyſis; and which conſequently may, under this point of view, be conſidered as the true principles and elements of all compounds. We ſhall ſee that theſe, like the firſt materials of all

natural productions, exiſt in great quantities at the ſurface, or within the globe. Their hiſtory forms the ſecond ſection of this work, and follows the firſt ſection, which treats of the generalities of chemiſtry, and conſtitutes the introduction to the ſcience.

7. The ſecond claſs of chemical bodies includes the binary compounds or leaſt complicated; all which are the reſults of the union of combuſtible bodies, of the preceding claſs, with the principle which unites with them during their combuſtion, and is alſo compriſed in that firſt claſs. Theſe are burned bodies. As all the properties of bodies placed in the firſt claſs depend on combuſtion, of which they are either the products or the ſubjects, it is extremely natural and methodical to arrange the burned bodies, or compounds, which reſult from their combuſtion immediately after the firſt. Theſe burned bodies form the third ſection of this work.

8. In the third claſs of chemical bodies are placed the earths and the alkalis; baſes which are named ſalifiable, becauſe, when combined with the bodies of the ſecond claſs, they conſtitute the ſalts properly ſo called. Though the greater number of theſe ſubſtances have not yet been decompoſed, we already poſſeſs too many facts reſpecting their hiſtory, and natural formation, to admit of a doubt that they are of the order of binary compoſition, and conſequently bear relation to the preceding compounds. We

ſhall diſcuſs this object more fully in the fourth ſection of this treatiſe, which is appropriated to them; beſides which, the number and importance of the combinations which they form with burned bodies, require that their baſes ſhould be placed immediately after the former.

9. To the fourth claſs of chemical bodies belong, by very natural order, the ſalts; formed by a determinate union of the burned bodies of the ſecond claſs with the ſalifiable baſes of the third. This claſs, conſiſting, at preſent, of a very great number of ſubſtances will be treated of in the fifth ſection of this work.

10. The fifth claſs of chemical bodies is appropriated to the metallic ſubſtances; conſidered individually and diſtributed methodically with regard to each other. They are firſt treated, in a general manner, and merely with regard to their relation to the other combuſtible bodies, of the firſt claſs. As ſimple matters, the metals are of too great importance with reſpect to every branch of knowledge; they form ſo many uſeful combinations, and their hiſtory would be too inaccurate and too incomplete, if it were not preceded by that of all the bodies examined before them, in order that they may poſſeſs a particular claſs in the chemical diſtribution of the products of nature. This fifth claſs will compoſe the ſixth ſection of the preſent treatiſe.

11. In the ſixth claſs I arrange thoſe mineral, or foſſil, ſtony, or metallic compounds, which

are found in the bowels of the earth, and which, conſidered as natural chemical combinations, of great importance to be known, ought to form a peculiar claſs among the productions of nature, when their mineralogy is required to be ſtudied. But all theſe foſſil bodies being treated of in one or other of the four preceding ſections, I have not thought it proper to include them in a particular ſection of this work.

12. In the ſeventh claſs of chemical bodies are placed vegetable compounds or materials of plants; combinations more complicated than all the preceding, which offer to our conſideration more numerous principles, more multiplied attractions, and more various alterations. The knowledge of theſe bodies leads to the phenomena which include the cauſes of vegetation, and the theory of vegetable philoſophy. They conſtitute the ſeventh ſection of this work.

13. Laſtly, the eighth and laſt claſs of chemical bodies contains the animal compounds, the ultimate term of the attractions and moſt complicated ſyntheſis;—ſtill more complicated than vegetables, more changeable, and more variable; of which the properties explained in the eighth ſection of this work, enlighten the philoſophy of animal ſubſtances, and require, in order to be accurately known, that we ſhould poſſeſs preciſe notions of all the bodies comprehended in the ſeven preceding claſſes.

14. In each claſs of chemical bodies, the ſeries of the ſubſtances, which belong to the

ſame, will be determined by their intimate properties, and by characters founded on their comparative nature or relative attractions; ſo that their mere diſtribution will exhibit a ſyſtematical outline of all the information which ſcience poſſeſſes reſpecting them.

15. In the theoretical expoſition of the properties, combinations, and decompoſitions of all the preceding bodies, we ſhall conſtantly obſerve, as I have already had occaſion to remark, that all the chemical phenomena preſented by theſe bodies, are owing merely to the effect of the relative attractions which exiſt between them; and that, on various occaſions, I have advantageouſly availed myſelf of the proportion, or relative energy, of thoſe attractions, for the methodical diſpoſition of the productions of nature belonging to ſeveral of thoſe claſſes.

ARTICLE XII.

Concerning the Nomenclature, and the Signs or Characters of Chemiſtry.

IN one of the firſt articles of this ſection, I have announced, that the nomenclature which was changed ſince the ſucceſs of the great revolution this ſcience has undergone, in 1787, differs totally from the ancient names adopted to denote the compounds and their principles, by preſenting a regular ſyſtem and a methodical arrangement of the accurate knowledge poſſeſſed by chemiſts. It is indiſpenſable, in this place, according to the order I have adopted in preſenting theſe elements, that I ſhould give an account of the progreſs of my co-operators and myſelf in the formation of this new language.

2. The firſt principle by which we were guided was, to connect the words with the things they were deſigned to repreſent. We began by baniſhing from the nomenclature all words deduced from the names of the inventors, from the medical or uſual properties, and, by ſtill ſtronger reaſon, from thoſe hypotheſes which had been imagined to explain facts ill obſerved, ill connected, and of which the relation with other facts was not yet diſcovered. By theſe means many ancient names, founded on the opinions of the alchemiſts, which were, in truth, groſsly erroneous, have diſappeared from among the new denominations.

3. The ſingularity of the ancient names—their ſource derived from every kind of prejudice and hypotheſis—their abſolute incoherence and independence of each other—their origin at different epochas, when they were propoſed to expreſs ideas different from thoſe they were afterwards employed to denote, forming the nomenclature at that time received, conſtituted a real chaos, which embarraſſed the ſtudy of the ſcience. The authors of the new nomenclature

immediately ſaw the neceſſity of creating a new method, which might connect all the chemical facts with each other, and preſent their ſeries in a ſyſtematical order. Hence it was that they gave to the reſult of their exertions the title of the methodical nomenclature.

4. The names which they adopted, frequently by borrowing terms from the ancients, and in every caſe by doing ſo when the ancient term expreſſed neither an error nor an hypotheſis which could not be ſupported, as well as the other words which they were obliged to form to expreſs bodies newly diſcovered, and unknown to the ancient chemiſts, are in general ſhort. The greateſt care has been taken to avoid thoſe circumlocutions and phraſes which have been formerly adopted, and conſtituted a language ſo difficult to be retained. The preciſion and conciſeneſs of the new expreſſions, render them eaſy to be pronounced and written, and afford the means of economiſing time, which is ſo valuable in the ſtudy and cultivation of the ſciences.

5. The terms of the methodical nomenclature are, in general, always relative to the nature of the body they denote, and have no relation to the inventor, like many of the ancient names, nor conſequently with the prejudices which the diſcoveries made in the times of alchemy had neceſſarily produced. When the nature of the body to which a name was to be

given was not exactly known, we have preferred to give thoſe names which expreſſed nothing poſitive, and could not give riſe to miſtakes. Experience proves, that early prejudices take ſuch ſtrong hold on the mind, and that it is ſo difficult to deſtroy them afterwards, that too much care cannot be taken to avoid every occaſion of producing them. Accordingly, the names, of little ſignification, or ſcarcely of any import, are derived either from the poſitive ſubſtances which afford the body in queſtion, or the place where it is found, &c.

6. The roots of new denominations, applied to expreſs bodies, alſo new or unknown to the ancient chemiſts, are conſtantly derived from the Greek language. To the advantage of bearing no relation with the words already known, and conſequently of being confounded with names belonging to different ſubſtances, they alſo unite the advantage of offering to the ear agreeable ſounds, eaſy to pronounce, ſometimes even harmonious; and, by theſe means, to approach the genius of the French language, of which, the ſoftneſs and eaſy pronunciation have made it a medium of intercourſe the moſt generally uſed in the world. Beſides which, by borrowing our definitions from the language of a poliſhed people, with whom the French have at all times borne the moſt ſtriking analogy; by cauſing chemiſtry to ſpeak the language of Ariſtotle and of Plato, we offer to the mind a fruitful ſource of eaſy recollection, and ſhow,

in words of a permanent etymology, the ſeries of ideas which they repreſent, and of which they are either the faithful impreſſions or the ſimple counterpart.

7. At the ſame time, while the propoſers have recourſe to the language of the Greek philoſophers for new terms, in the uſe of which they have been extremely ſparing, the whole number adopted in the methodical nomenclature not exceeding ſix or eight, they have alſo conſulted, at the ſame time, the genius and progreſs of the French language. They have not adopted a ſervile imitation or ſimple tranſlation of the Greek words which they have tranſported into their language. Thoſe words being employed only in part, are appropriated to the rules of the grammar of their country. They were deſtined only to bring to mind ſome ſtriking and well-characterized properties, and the ancient idiom of Athens will be found to no greater extent than is neceſſary to enlighten the underſtanding of thoſe who read or pronounce them. Thoſe terms ſuppoſe only the ſlighteſt, the moſt ſimple knowledge of the principal Greek words, a knowledge which muſt form part of the liberal education of a native of France, who is deſirous of devoting himſelf to the ſtudy and cultivation of the ſciences.

8. In general, the names applied to ſimple bodies, or thoſe which have not yet been decompoſed are merely ſimple words; each of thoſe bodies is expreſſed by a ſingle word, and this

word is almoſt always the term which has been long adopted. The propoſers of this nomenclature have made it a law, ſcrupulouſly to preſerve the ancient names in all caſes wherein the ſubject, denominated and long known, preſented in its ancient denomination no one of the vices which they were deſirous of avoiding. When the ancient term was found imperfect in thoſe reſpects, they have frequently been content to modify the received term in order to correct its defect, but without altering its nature ſo far as to render it difficult to be again known. New words have not been applied to ſimple bodies excepting in the caſe of abſolute neceſſity; that is to ſay, when thoſe bodies were formerly entirely unknown, and being the products of new diſcovery were conſequently in poſſeſſion of no denomination in the old nomenclature.

9. To compound bodies they have in general given compound names, formed to ſhow the kind and nature of their component parts; ſo that by pronouncing thoſe terms we expreſs without error and without obſcurity, what are the ſubſtances of which we ſpeak without being required to make thoſe efforts of memory which the chemical nomenclature formerly demanded, when its terms bore no relation, or a very remote relation with the bodies concerning which it treated.

10. There are, nevertheleſs, ſome compounds which, in their nature, are ſo complicated, that they would have required a great number of

words to expreſs their compoſition. In this caſe, as will be ſeen in the vegetable or animal ſubſtances, the method has been adopted of deducing their name, either from the ſubſtances which afford them, or ſome determinate obvious properties ſuſceptible of characterizing them without error.

11. The chemical names of the methodical nomenclature poſſeſs another advantage, namely, that they are few, notwithſtanding the great number of ſimple or compound bodies, which they are employed to expreſs. For this purpoſe, the method of varying the termination is uſed to expreſs the different ſtates of the combined ſubſtances; which are diſpoſed in ſuch a manner as to announce all the differences obſervable in their combinations. Theſe terminations are the ſame in analogous compoſitions, and the ſound they afford is ſufficient to exhibit the nature of the compoſition to which each of them is appropriated.

12. The union of principles which I have here exhibited, forms a ſyſtem of denominations eaſy to be retained, and of which totality preſents, in its ſeries of names, the exact and faithful outline of the facts which conſtitute the whole of the ſcience. It follows therefore, that the chemical language compoſing the methodical nomenclature, is the ſimple expreſſion of the phenomena; that it admits of nothing arbitrary, and cannot be conſidered but as the repreſentation of the things themſelves. It has the additional

advantage of embracing not only the known facts, but alſo of adapting itſelf with great facility to all the diſcoveries yet concealed in the boſom of nature; as the ſeries of thoſe diſcoveries which have been made in the courſe of eleven years from 1787, the time of the eſtabliſhment of this nomenclature to the moment in which I write the preſent, ſufficiently proves. This is the firſt example of the creation of a ſyſtematic and analytical language in any ſcience. The happy ſucceſs which has followed its admiſſion, permits us to hope that a uſeful application of this proceſs will be made to the other philoſophical ſciences, and the attempts already made in the nomenclatures of anatomy and mineralogy juſtify this hope.

13. The ſyſtem of methodical nomenclature muſt neceſſarily require a change in the chemical ſigns or characters, of which the uſe is often ſo advantageous for the conciſe expreſſion of phenomena, and reſults of experiment, which conſtitute a kind of univerſal language independent of the different idioms, like the letters in algebra. The old chemical characters were myſterious emblems; a kind of hieroglyphics which the alchemiſts made uſe of to involve and conceal their operations; their origin being fixed in an opinion no leſs erroneous than ſingular, they were diſtinguiſhed, at the ſame time, by falſehood and inconſiſtency. They were founded on the doctrine of ſignatures, ſympathies, and pretended relation between the ſtars and ſubluuary

nary bodies, or the relations of theſe laſt to each other in their moſt diſcordant properties. They could only, therefore, be conſidered as the falſe repreſentations of a multitude of hypotheſes more or leſs abſurd. For a long time, and more eſpecially ſince the epoch in which chemiſtry threw off the yoke of alchemy, natural philoſophers have uſed them with regret, and have inceſſantly deplored the ridiculous falſity of theſe inſtruments. The leaſt of their defects was that they offer nothing ſyſtematical or comparable between each other; and this inconſiſtency became more ſtriking, in proportion as the progreſs of ſcience made it neceſſary to add other ſigns to expreſs ſubſtances newly diſcovered; as may be ſeen in the tables of chemical attractions, publiſhed by Bergmann, in which that illuſtrious chemiſt has, nevertheleſs, attempted to ſubject the form of the characters to ſome method. But no chemiſt could ſucceed in changing thoſe ancient ſignatures and fantaſtic emblems, while the ſcience itſelf, being no leſs obſcure and fantaſtic in its nomenclature, afforded them no ſolid baſis to produce a change ſo deſirable.

14. One of the advantages of the new methodical nomenclature is, that it has not only promoted, but even imperiouſly demanded this renovation of characters. This nomenclature alone, by its ſyſtematic and regular arrangement, was capable of directing the formation of ſigns intended to exclude, and ſo advan-

tageouſly to replace the ancient hieroglyphics. Citizens Adet and Haſſenfratz undertook this work at the very moment when the methodical nomenclature was propoſed, and they have performed it with all the clearneſs, ſimplicity, and method, which was to be expected from their talents and information. Without explaining theſe ſigns in this place, becauſe the deſcription and explanation would be entirely diſplaced, I ſhall content myſelf with obſerving, that they perfectly agree with the methodical nomenclature; that the characters deduced from ſimple figures, the right line, the ſemi-circle, the triangle, and the ſquare, placed in different manners, expreſs the ſimple ſubſtances;—that each of thoſe characters forms a genus deſigned to repreſent a correſponding genus of bodies, of which the ſpecies are afterwards determined by their relative poſition, and the addition of the initial letter of the name which belongs to each; that by uniting or connecting two of theſe ſimple bodies, the authors have thus repreſented binary compounds, of which the image itſelf traces, by the relative diſpoſitions, the two connected ſigns of the proportion of each of their component parts; that, in this manner, they have ſucceeded by an ingenious and ſimple method to reſolve the greateſt part of the important problem they had propoſed to themſelves, namely, to exhibit by figures and emblems, the ſimple or compounded nature of bodies, their order and compoſition, or the number of their component parts, as well as the general proportion of the ſame.

15. Theſe ſimple ſigns, no leſs diſtinct and eaſy to be fixed in the memory, than to be written, by forming a methodical and ſyſtematic ſeries of chemical characters, founded on the ſame baſis as the nomenclature itſelf, and, like that nomenclature, intended to repreſent without any arbitrary ſuppoſition or of hypotheſis, all the reſults and experiments,—poſſeſs likewiſe, in common with that nomenclature, the advantage of preſenting, not only the knowledge we poſſeſs, but alſo by their generality and the various diſpoſitions of which they are ſuſceptible, they afford future materials to deſignate new bodies, even among the undecompoſed ſubſtances accordingly as the ſcience ſhall enrich itſelf by new diſcoveries. It is more particularly in this reſpect, that, like the new denominations, theſe characters are diſtinguiſhed from the ancient hieroglyphics which, being altogether hypothetical or erroneous, become more and more remote from every ſyſtematical order, in proportion to the neceſſity of forming new characters to expreſs ſubſtances before unknown.

SECTION SECOND.

Concerning ſimple Bodies, or ſuch as have not yet been decompoſed.

ARTICLE I.

General Conſiderations reſpecting ſimple Bodies; their Number; their Claſſification.

1. ALL the bodies in nature, conſidered with regard to the manner in which they are affected in chemical operations, preſent themſelves to us either as ſimple or as compounded;—that is to ſay, the latter are capable of being acted upon by the different methods of analyſis, and can be ſeparated into bodies leſs compoſed, which are called principles, in compariſon with thoſe from which they are obtained; whereas the former, treated in the ſame manner, do not afford any principle more ſimple than themſelves, and are not capable of being analyſed.

2. Whenever, therefore, we uſe the denomination of ſimple bodies in chemiſtry, the term is to be underſtood only of bodies not yet decompoſed. We cannot pretend that theſe bodies are really ſimple in themſelves, or that they

are not formed of other elements ſtill more ſimple. We can only affirm, that in all the experiments of the ſcience, theſe bodies are found to act as if they were ſimple; that they cannot be decompoſed by any of our methods; that they reſiſt every ſpecies of analyſis, and can only be combined with other bodies, or be made to undergo various ſyntheſes.

3. Natural bodies, conſidered under this point of view, preſent to chemiſts very great differences from the doctrines which were formerly held reſpecting them. Moſt of thoſe which were formerly conſidered as ſimple, and as the elements of all other bodies, are found to be more or leſs compounded; while of thoſe, which were formerly ranked among the claſs of compounds, there are a great number which are really not decompoſable, and can only be placed among ſimple bodies.

4. We muſt not give to this diſtinction, though eſtabliſhed in modern chemiſtry, a greater degree of extenſion or latitude than it is really entitled to, or aſcribe to the chemiſts who admit it, notions which they do not entertain. They do not in truth expreſs by the words ſimple bodies, any thing more than the reſult of a chemical fact, which proves that thoſe bodies reſiſt every attempt at analyſis, and are only known by the part they form in combinations. They do not confound them either with the principles or the elements of the ancient chemiſts. It is true that they no longer

treat of thoſe principles or elements in particular, becauſe they can perceive nothing in the theory, which formerly admitted them, but looſe hypothetical notions far from poſſeſſing any agreement with the ſevere proceſs of reaſoning, and the doctrine which follows from their accurate operations.

5. The bodies which have not hitherto been decompoſed, amount to near thirty. We ſhall even find that there are ſeveral others placed in the following ſections, which may be arranged in the ſame claſs which enlarges the number to more than forty; but thoſe ten or twelve laſt ſubſtances, without being decompoſable, do, nevertheleſs, approach ſo nearly to other bodies in their chemical properties, which are known to be compounded, that it is hardly poſſible to ſeparate them, or to give up the expectation that we ſhall ſucceed in decompoſing them, long before that period in which thoſe other bodies, which are at preſent reckoned among ſimple ſubſtances, ſhall be known with regard to their intimate nature, or their laſt conſtituent particles.

6. The ſimple or undecompoſable bodies, which are arranged and examined in this ſecond ſection, are light, caloric, oxigen, azote, hidrogen, carbon, phoſphorus, ſulphur, the diamond, and metals, which comprehend twenty-one different ſpecies diſtinct from each other. If we place immediately after oxigen and azote, the atmoſpheric air, which is the compound of

theſe two baſes, we ſhall have eleven bodies forming the ſubject of the eleven following articles of this ſection.

7. By comparing together the ten genera of ſimple bodies, of which the number, the relative diſpoſition, and the denominations, are here given, we ſee that the greater number of them are combuſtible or inflammable matters; that another genus is ſolely and excluſively neceſſary to the combuſtion of the firſt; that a third comprehends that ſubſtance which favours or provokes combuſtion, and laſtly, that a fourth genus is almoſt always diſengaged in the combuſtion, and is as it were the product of this phenomenon.

8. All ſimple bodies, therefore, bear relation to combuſtion, either as products, or as favouring that proceſs, or as being immediately and neceſſarily ſubſervient thereto, or as themſelves undergoing or being the proper object of that proceſs. The one are the phenomena or acceſſories, the other, are the conditions or the ſubjects.

9. It muſt follow, from theſe two conſiderations (Nos. 7 and 8), that combuſtion is one of the greateſt and moſt frequent phenomena of nature; ſince all that relates to the hiſtory of the ten ſimple bodies belongs to it excluſively. Modern chemiſtry, therefore, after having placed this truth in its full light, has eſtabliſhed one of the principal foundations of the ſcience.

10. The effect, or mode of action, which is attributed to each of the ten ſimple bodies in the act of combuſtion, of which they embrace the vaſt phenomenon, is diſtributed in the following order: Light is one of the moſt conſtant products, and it is the preſence of this being which moſt men expreſs by the words flame, inflammation, inflammability. Caloric, beſides that it is almoſt always the product, is found, like light, to favor, to produce, to excite, to determine, and to accelerate the proceſs. Oxigen is the principal agent, and conſtitutes it by an indiſpenſible neceſſity for its preſence. Azote, hidrogen, carbon, phoſphorus, ſulphur, diamond, and the metals, are the objects, the ſubject, or the true inſtruments of this proceſs.

11. There is ſtill another important conſideration, on the totality and compariſon of the ten genera and ſimple bodies, which relates to the great maſs of ſome of them; the immenſe ſpace which they occupy on the terreſtrial globe, and the little relative abundance of others, as well as their condenſation and diſpoſition on a few points of the earth merely. Light and caloric occupy the entire ſpace of the univerſe, and are every where diffuſed; oxigen and azote compoſe the atmoſphere, which they fill. The ſix other genera of ſimple bodies, being all combuſtible ſubſtances, properly ſo called, exiſt in much ſmaller quantities, and particularly in much ſmaller maſſes, than the

former, and are diſſeminated or depoſited, in a denſe ſtate, in ſome of the ſtrata of this globe.

12. The four firſt bodies therefore act generally, and during every inſtant of time, on all other natural bodies, and accordingly enter into the compoſition of a multitude of productions. They may therefore be regarded as holding, in the new chemical ſyſtem, the ſame rank as was formerly given to the elements. Nevertheleſs, from their reſemblance to the four firſt, in the common point of view, many of the ſix following genera of ſimple bodies, though leſs abundant than the former, may and muſt be equally conſidered as forming the baſes and elements of many of the compounds, which will be examined in the following ſections. This propoſition is more particularly applicable to hidrogen and carbon, the principles of a great number of complicated compoſitions, and may even be extended to phoſphorus, ſulphur, and the metals, which chemical analyſis diſcovers in many mineral or foſſil compounds.

Article II.

Concerning Light.

1. LIGHT being the firſt body, of which the properties are to be examined, muſt alſo be that of which the hiſtory ſhould apparently be the moſt conciſe; becauſe the chemical properties themſelves being merely the reſult of the intimate action of, at leaſt, two bodies upon each

other, and no one body having been either deſcribed or examined, previous to the object of our preſent obſervations, there can yet be no means, or agent, or re-acting ſubſtance, from which we can derive the character of this principle.

2. Nevertheleſs, beſides ſome of its phyſical properties, of which we muſt give a ſketch in this place, it is neceſſary to take a general view of light, not only as to its influence upon certain individual bodies, but alſo upon the whole of natural ſubſtances, in order that we may obtain a proper notion of its general or univerſal action, and deſcribe certain conſtant effects, which may ſerve as characters to eſtimate its power and diſtinctive qualities.

3. Two opinions are maintained by naturaliſts and philoſophers reſpecting the origin of light. Some, with Newton, derive its origin from the ſun and the fixed ſtars, without embarraſſing themſelves to explain how it happens that this luminary is not exhauſted; becauſe they account for this by the extreme ſubtilty of the luminous fluid; others, with Deſcartes and Euler, place its exiſtence in a fluid, called the ether, a thouſand times rarer, at leaſt, than air, which they place in the immenſity of ſpace, and to which the extreme celerity of the motion of the ſun and the ſtars communicates the rapidity of its progreſs.

4. In either hypotheſis a fluid is admitted; but when we conſider the effect of light upon

our eyes merely as the product of the concuſſion or undulation of this rare fluid, like ſound which conſiſts only in the vibrations communicated to the ear by ſonorous bodies, put in motion according to the ſecond hypotheſis of Euler, we manifeſtly depart from the chemical facts, already admitted reſpecting light, which proves that it acts like a body, and that it obeys the force of attraction.

5. In the exhibition of the properties of light, beſides the beauty of the brilliant ſpectacle which it preſents to our eyes, in the experiments to which natural philoſophers ſubject it; every reſult, concerning the ſingular rarity of this body, ſeems to be miraculous, as well as the inconceivable velocity with which it is animated, and the changes it produces in moſt of the ſubſtances on which it impinges, or through which it paſſes.

6. The prodigious velocity of light, calculated by Geometers, is ſuch, as that it paſſes through forty thouſand myriameters, or eighty thouſand leagues per ſecond; a ſwiftneſs which man can ſcarcely conceive, becauſe there is no other velocity to which it can be applied in the way of compariſon. Sound paſſes through more than three hundred and twenty-five metres in a ſecond, and the velocity of light is, according to Euler, nine hundred thouſand times more ſwift. It arrives to us from the ſun in eight minutes, and, neverthleſs, according to ſome Geometers, light, from its departure from the

neareſt of the fixed ſtars, which is, in truth, at leaſt four hundred thouſand times more remote than the ſun, is near ſix years in its progreſs to our eyes; ſo that a ſtar placed at that diſtance, would be ſtill viſible for ſix years after its deſtruction, ſuppoſing that proceſs to take place. How grand and ſublime are the meditations, ſuggeſted by this object, on the immenſity of ſpace, the boundleſs extent of the univerſe, the vaſt number of globes which traverſe through it, and the duration of time which they meaſure in their ſilent march!

7. Light, on its arrival or incidence upon our globe, is inflected, and approaches to the perpendicular of the plane of the body it paſſes through, when it is received in a denſer medium from one which is more rare. In this manner it is that light is condenſed by Lenſes; the phenomenon itſelf being known under the name of refraction. The fact itſelf proves that light is ponderous, or is attracted by bodies, though we have no balance ſo accurate as to determine its weight.

8. It paſſes through certain bodies, denominated tranſparent, and undergoes a refraction which is proportioned to the denſity of thoſe bodies, if they be incombuſtible, or the compound ratio of their denſity and combuſtibility, if they be combuſtible. It was, by the meaſure of this refractive force that Newton conjectured, long before the experimental diſcoveries of chemiſtry, that the diamond is a combuſtible body,

and that water contained a principle of inflammability.

9. It is ſtopped by the ſurface of opaque bodies, and when reflected by that ſurface, it moves again in a direction contrary to its firſt motion, or returns in an angle nearly equal to that of its incidence. Hence it is concluded to be the moſt elaſtic ſubſtance in nature.

10. The viſibility of all bodies, and the ſpectacle which the univerſe offers to man, not only depend on this motion of light from their ſurface, and its intromiſſion in our eyes, where it forms the image of objects on the retina, ſo as to inform us of their exiſtence, their figure, and their relative diſtance; but it is alſo the cauſe of thoſe colours with which it truly paints all the bodies which are the ſubject of the faculty of viſion.

11. When light paſſes through tranſparent and denſe bodies, it is ſcattered or divided into a great number of coloured rays, of various tinges, which are particularly referred to ſeven colours, called primitive, and placed in the following order, from the lower to the upper extremity of the ſolar ſpectrum; that is to ſay, the whole of the coloured ranges which are formed by the light received in a darkened chamber, after its paſſage through a glaſs priſm, and projected on a white paper or other ſubſtance. Theſe ſeven ranges are the red, orange, yellow, green, blue, indigo, and violet.

12. Does this effect of coloration,—for the colours of opaque bodies are attributed to a ſimilar diſperſion of light from their ſurface,—does this depend on the decompoſition of light as ſome philoſophers have thought? Light, according to this hypotheſis, would be a compound body, and ought no longer to be placed in our firſt ſection, or, at leaſt, it ought not to occupy the firſt place, as the moſt ſimple and moſt abundant of natural bodies. But no fact has yet proved this pretended decompoſition of light. The opinion of Euler, who conſiders the generation of colours as the product of motion, or vibrations varied according to certain proportions, like the tones which are diſtinguiſhed in ſounds, agrees much better with the phenomenon.

13. According to this laſt doctrine, the ſurface of coloured bodies, when it receives the luminous rays, communicates to them, agreeably to the proper nature of the body itſelf, certain vibrations, which cauſe them to produce in our eyes the ſenſations of different colours. Theſe colours are ſo proportioned, with reſpect to each other, as to their velocities and the varied ſenſations they produce, that ſome irritate and offend the organ of ſight, while others communicate pleaſure and delight. Painters are well aware of theſe agreements or diſagreements, and, like muſicians, they expreſs their exquiſite ſenſations in this reſpect, by the words harmony, tone of colours, &c.

14. A ſimilar effect takes place in denſe tranſparent bodies, more eſpecially in priſms through which light paſſes. Theſe bodies, which are far from being homogeneous as to their particles, agitate the luminous rays in various manners, and cauſe them to vibrate ſo as to repreſent in our eyes thoſe gradations of colour which are nothing but the rays themſelves moved with different and proportional velocities. Hence it happens that the diſſimilarity of the ſtrata, bubbles of different thickneſſes, and foreign tranſparent bodies, interſperſed between the laminæ of glaſs, of tranſparent ſtones, produce iriſes, coloured reflections, rings, &c. among which the beautiful colours of bubbles formed in ſope afford a prominent inſtance.

15. Some opaque bodies ſeem to reflect all the light from their ſurface, communicating to its maſs an equal and uniform motion. Theſe are white and brilliant bodies. Others, on the contrary, ſeem to abſorb it totally, and to retain it without communicating any motion. Theſe are dull obſcure bodies. The extreme of this laſt phenomenon is the black ſhade, or perfect obſcurity.

16. Though all the preceding properties are phyſical, nevertheleſs, many of them, ſuch as refraction, the ſtrong coloration, and obſcurity, approach to chemical properties, becauſe they announce an attraction of compoſition between light and the different bodies, which, together

with this ſubſtance, contribute to produce chemical phenomena.

17. There is no reaſon to doubt but that light, as well as all natural bodies, does obey the force of attraction; that it enters into the combination of various compounds, and is diſengaged in many decompoſitions. So that when we obſerve it diſappear within ſuch bodies as admit it; as when a ſtrong ray of light touches any ſubſtance, and returns much leſs brilliant, or when, on the contrary, we obſerve in many chemical operations made on obſcure bodies, that they become illuminated, inflamed, and emit this principle at the moment the combinations take place, we muſt conclude, that in the firſt caſe it becomes fixed and combined, and, in the ſecond, diſengaged, ſet at liberty, and emitted from the compounds which it forms. Such is the general cauſe of flame and phoſphoreſcence.

18. We ſhall ſee in the following articles, that it, in fact, eſcapes from one of its moſt frequent natural combinations during combuſtion, and that it diſappears, is fixed, and combines in every caſe where the reverſe phenomenon takes place, which I have denominated decombuſtion; ſo that one of the moſt uſeful and moſt ſtriking expreſſions which can be employed, and of which I ſhall very frequently avail myſelf to repreſent the action and chemical influence of light, will be the word to unburn.

19. Though we cannot explain the manner in which light acts upon vegetables and vegetation, the ſlighteſt attention to the phenomena which accompany it, and the reſults which characterize it, are ſufficient to prove that it has a great influence in the production of theſe phenomena. All plants which grow in the ſhade are pale, ſoft, watery, and inſipid, as if hydropſical. In this ſtate, they are ſaid to be bleached or blanched. Gardeners avail themſelves of this effect of the abſence of the ſun and the light, either by making plants grow in ſubterraneous places, or by tying their leaves cloſe together in order to procure white and ſoft vegetables.

20. All plants, on the contrary, which are much enlightened, particularly thoſe on which the direct rays of the ſun fall, as for example, under the equator, grow more rapidly and become upright, ſolid, coloured, ſapid, and inflammable. Theſe laſt are at the ſame time very odorant, and ſo acrid that many of them are poiſonous. A ſimilar difference appears in our gardens and fields. Such plants as grow concealed beneath the thick graſs, or the ſhady foreſts, or ſhaded by rocks, are contracted, ſmall, thin, watery, and pale. The ſame plants are hard, ligneous, bitter, or very ſapid, when they grow in the open fields.

21. It is no leſs evident that light acts on living animals; that the preſence of the ſun is neceſſary to maintain their life and healthy

ſtate. For, not to mention the example of thoſe animals which eagerly court the preſence of this enlivening luminary, it is known that men, long kept confined in cloſe and obſcure places, languiſh, become weak, loſe their colour, their activity, their vital energy, and that their abſorbent ſyſtem becomes loaded with fluids, which the white veſſels can no longer move with ſufficient celerity.

22. We do not, in this place, attempt to determine, what is the theory of the action exerciſed by light on ſuch minerals as it unburns, and alters their colour and their nature; on thoſe vegetables in which it produces the green colour, the oil and the reſins, or on animals of which it enlivens and ſupports the exiſtence. This will be the ſubject of ſeveral articles in the following ſections. In the preſent, we have endeavoured only to exhibit a general proof of the chemical influence exerciſed by light, and the attractions of compoſition to which it is obedient. It is evident, that there cannot be the ſmalleſt doubt on this ſubject, after what has been ſaid. It is not, therefore, poſſible to think with Euler, that light conſiſts, like ſound, in the mere vibrations of the ether, produced by the motion of the ſun and the fixed ſtars; for we might in vain attempt to produce, by means of ſound, chemical facts analogous to thoſe which owe their origin to light.

ARTICLE III.

Of Caloric.

1. THE matter which produces heat, and is named caloric by chemiſts, is, with light, the moſt abundantly diffuſed of all bodies through the univerſal ſpace. It muſt conſequently act a very important part in the phenomena of the world. Philoſophers have accordingly conſidered it in all ages under the names of fire, heat, and matter of heat, as the ſubject of their moſt profound and ſublime meditations. They have conſidered it, as it were, the ſoul of the univerſe, the firſt mover of a numerous progreſſion of events, the general ſource of all motion, fluidity, elaſticity, and even life itſelf. Without this principle, according to them, inert repoſe and death would pervade the ſcene of the world. And it is for reaſons of this kind that I have placed it the ſecond among natural bodies in the order I have adopted.

2. It is well known that the word heat, denotes the ſenſation produced by a certain particular body; that this term can give only a vague and indeterminate idea, becauſe there is nothing which varies ſo much as our ſenſations; but that, nevertheleſs, it is agreed by all, that the abundance of the calorific principle applied or accumulated in our bodies, excites the ſenſation

tion of heat, while the diminution or ſubſtraction of the ſame principle is attended with that of cold. It is this principle, ſuſceptible of increaſe and diminution in bodies, which is denoted by the term caloric.

3. Philoſophers and naturaliſts have entertained two opinions reſpecting the cauſe of heat. Some have conſidered it merely as the conſequence of motion excited among the particles of bodies; while others have attributed it to a ſelf-exiſtent body; and chemiſts, who ſtudy its progreſs, determine to a certain point its quantity, or at leaſt its proportion in different ſyſtems of bodies compared together, and even eſtimate its various attractions, have a thouſand means of accumulating the proofs of the ſecond opinion. It is to them that the term caloric owes its origin, which they have adopted to diſtinguiſh the body that produces the ſenſation, from the ſenſation itſelf or the heat excited.

4. In natural philoſophy the properties of caloric are examined, and its preſence ſhown by the ſeparation of the particles of all bodies, which it produces by inſinuating itſelf between them; it is proved that it penetrates all bodies, none of which can oppoſe any obſtacle to its reception; that, in common with all other fluids, it tends to an equilibrium or level; that it dilates ſolids, and rarefies liquids; that the dilatation of the former, thus effected, produces their liquefaction; that the rarefaction of the ſe-

cond terminates in the ſtate of elaſtic fluidity; that in whatever quantity it is accumulated in bodies, it does not add to their abſolute weight; that it diminiſhes their ſpecific gravity by adding to their volume, and that we can, to a certain point, exhibit or expreſs the quantity of caloric by the meaſure of the expanſion, or dilatation which ſolids or liquids undergo. This laſt method conſtitutes pyrometry and thermometry, the inſtruments of which are called pyrometers and thermometers.

5. The notions of chemiſts reſpecting this firſt quality of caloric are, in ſome reſpects, more accurate and poſitive; its dilating or rarefying action is conſidered as the effect of attraction or a true combination. It is obſerved, that caloric, in proportion as it penetrates and dilates bodies, does really combine with them, more particularly when it cauſes them to change their ſtate: that is to ſay, when it cauſes them to paſs from the ſolid to the liquid ſtate, or from the liquid to the elaſtic ſtate:—that in this manner during the fuſion of ſolids, theſe remain conſtantly at the ſame temperature, or in the ſtate of heat they had acquired before their fuſion, until they are rendered completely fluid;—that from this ſtate after the firſt rapid formation of vapours, liquids do not continue to acquire heat as long as any portion remains in the ſtate of liquidity;—that this ſtationary temperature is owing to the caloric introduced and accumulated in bodies where it becomes

really

really fixed, and combines in ſuch a manner as not to aſſume the form or ſtate of heat until thoſe bodies, being ſaturated, become merely traverſed by the caloric which is then added, and paſſes forth in the form of heat.

6. Chemiſts have the ſame notions reſpecting the conducting property of bodies with regard to caloric; that is to ſay, the ſpeed with which certain bodies are penetrated by caloric, or become hot, or the ſlowneſs with which it paſſes through certain others that employ a longer time to have their temperature raiſed. Admitting that the former, as good conductors of caloric, receive this principle much more readily between their particles and that they retain it much leſs powerfully than the latter, they attribute this effect to their chemical attractions, and, in fact, the conducting property appears to follow the ratio of the mutabilities of the bodies by heat; ſo that a cylinder of charcoal, which may be held between the fingers at a ſmall diſtance from an ignited part without burning them, is ſcarcely at all dilatable, nor fuſible, nor volatile; and a cylinder of metal which becomes ſpeedily heated in its whole length, dilates much, is fuſible, and riſes by the continued action of fire.

7. It is not in the direct ratio of the rarity of bodies, or the inverſe of their denſity that bodies are dilatable by caloric as philoſophers have long imagined. Since accurate experiments have been made on the dilatability of

ſolids, the rarefaction of liquids, and the expanſion of gaſes by caloric; ſince the nature, the fabrication, the true properties, and the uſe of thermometers have been better known, it is admitted that this augmentation of volume in bodies by caloric, depends on the attraction they have for it, and the kind of alteration it is capable of producing in them. So that a metal as a fuſible ſubſtance, is more dilatable than a ſtone which is leſs fuſible or altogether infuſible; and alcohol, which is liquid, inflammable and very volatile, is more rarefiable than water which has much leſs volatility.

8. It has been diſcovered by modern experiments, that, in order to heat different bodies to the ſame degree, it is neceſſary to accumulate in each of them different quantities of caloric, or, which is the ſame thing, that theſe different bodies elevated to the ſame temperature, do not contain the ſame quantity of caloric. So that thermometers do not really indicate the true proportion of this principle in bodies, as has long been imagined. Thus the property, which we call the temperature of bodies, does not ſhew the meaſure of their caloric, but merely the degree of dilatation, which the caloric they contain in a diſengaged ſtate is capable of producing in the ſolid or liquid, of which the thermometers are formed.

9. In order to form a true conception of this important property of bodies with regard to caloric, we muſt diſtinguiſh this laſt in two

ſtates. The one, in which it is at liberty, conſtituting what we call heat, penetrating bodies in fact, but merely paſſing through them with greater or leſs velocity according to its accumulation, to ſuch other neighbouring bodies as contain a leſs quantity. The other ſtate in which it is combined, concealed, or latent, without exhibiting its preſence by the thermometer. When any body whatever is expoſed to caloric, it is either capable of combining with it in different proportions, or it is not. Bodies of the firſt kind being much more numerous than the ſecond, as ſoon as moſt of them are heated, the caloric which penetrates and dilates them combines in a greater or leſs quantity with their particles, a portion always remaining at liberty, while another becomes latent; ſo that as theſe two portions conſtantly vary in their relative magnitudes according to the different nature of bodies, it follows that there muſt be a correſponding difference between the riſe of the thermometer and the true quantity of caloric contained in bodies.

10. Attempts have been made to explain this property, by ſuppoſing that the particles of caloric, which are interpoſed between thoſe of bodies, or among their pores, find thoſe pores more or leſs numerous, and of different magnitudes. So that by conſidering this introduction of caloric with reſpect to bodies, as reſembling the contents of a veſſel with regard to fluids with which it may be filled, the property of con-

taining more or leſs of caloric, and of requiring different quantities to arrive at the ſame elevation of temperature, has been termed capacity for heat or caloric. This is the ſimple idea given by Lavoiſier in his treatiſe of chemiſtry.

11. But if the capacity of bodies for caloric were ſimply the meaſure of their contents and depended only on the number and magnitude of their pores, it would neceſſarily follow that their lightneſs with reſpect to each other would be a certain indication of this capacity. But nothing would be more falſe than this eſtimate; for there are many bodies known in chemiſtry which, though ſolid, contain more ſpecific heat than certain elaſtic fluids.

12. Every fact, on the contrary, announces that this capacity is the reſult of a chemical force of the attraction of the particles of caloric to the particles of different bodies, and of the change which theſe two kinds of particles undergo, by their approach and mutual condenſation to a greater or leſs degree according to their relative attraction. When caloric is introduced into a body, its firſt effect is to increaſe the diſtance between its particles, becauſe its own particles lodge themſelves between thoſe of the body itſelf, and enlarge, by their elaſticity, the ſpaces which ſeparate them; but ſpeedily as they accumulate they undergo a compreſſion, which is greater in proportion to the attraction exiſting between the particles of bodies and thoſe of caloric. The accumulable quantity is, therefore, according to the ratio of

its attraction for the particles among which it penetrates; and the capacity for caloric in bodies is nothing more than an expreſſion denoting their attraction for that principle.

13. This effect of the ſeparation of the particles of bodies by caloric, and the compreſſion of the proper particles of caloric between thoſe of the bodies in which it is accumulated, announce a great elaſticity and ſpring in thoſe laſt particles. Natural philoſophers and modern chemiſts, therefore, conſider caloric as the moſt elaſtic, the moſt compreſſible, and the moſt dilatable ſubſtance in nature; and accordingly, they avail themſelves of this property to explain the elaſticity, the compreſſibility, and the ſpring communicated in ſo high a degree to all bodies by the accumulation of this principle.

14. As the capacity for caloric varies in different bodies, and as from this circumſtance each body, though elevated to the common temperature, contains a different quantity of caloric, the ratios of theſe quantities have been denominated ſpecific heats. Theſe ſpecific heats are meaſured, 1. By mixing, after the method of Crawford, two bodies in the ſame ſtate, that is to ſay, both ſolid or both liquid, after having heated them to different temperatures, and taking notice of the temperature they acquire by mutual communication. The differences between this temperature acquired by the mixture, and that which each of the bodies had before their contact, give the ratio of their capacities.

But it is neceſſary, in order to juſtify this calculation, that the bodies themſelves ſhould not act chemically upon each other, and it is alſo neceſſary to prevent a portion of their caloric from being carried off by the veſſels in which the experiment is made; whence it follows that this method is often deceptive and very frequently impracticable. 2. The proceſs of La Place and Lavoiſier is much more uſeful. It conſiſts in heating different bodies to the ſame degree of the thermometer and afterwards plunging them in an inſtrument which may be imagined to be an hollow ball of ice, or ſolid water, where they are to be kept until they have acquired the temperature of Zero; and an account is to be kept of the quantity of ice, which each of them has cauſed to become fluid in order to arrive at this ſtandard temperature. The inſtrument uſed in this excellent operation is called the calorimeter.

15. By multiplying experiments with the calorimeter, modern chemiſts have aſcertained, that bodies vary in their capacity for caloric, by changing their ſtate, that is to ſay, by paſſing from the ſolid to the liquid ſtate, and from this laſt to the ſtate of gas. Hence it is, that two equal portions of the ſame body, in the ſame ſtate, two hectograms, for example, of liquid water, unequally heated, the one, for inſtance, to 30 degrees of the thermometer, and the other to ten, acquire, when accurately mixed, the mean temperature between both, that is to ſay, 20 degrees; whereas, equal quan-

tities of the ſame body, in two different ſtates, the one ſolid and the other liquid, heated unequally, do indicate, by the common temperature, after their mixture, a deviation from this law. Thus, one hectogram of ice (or water frozen to the temperature of Zero) and one hectogram of liquid water, at 60 degrees, indicate, by their mixture, the temperature of Zero, or 0°.

16. Every portion of caloric, which being at liberty and imparting heat, is found to diſappear in combination, and no longer to afford the ſame temperature as in the laſt reſult mentioned in the preceding paragraph, does itſelf enter into combination, loſes its character and property, no longer paſſes through other bodies, nor raiſes the thermometer, but has paſſed from a ſtate of liberty or diſengagement to a ſtate of compoſition. This caloric is become latent, according to the happy expreſſion of Black. It may be meaſured as in its other ſtate, but by proceſſes more complicated and leſs immediate. It is announced by the diminution of temperature or exhibition of cold, which accompanies all the combinations in which caloric is in this manner engaged.

17. All caloric, which from a combined or latent ſtate, paſſes to the ſtate of free caloric, ſenſible to the thermometer, and meaſurable by the quantity of ice it may fuſe, is the product of the deſtruction of a former combination, or of the change of chemical ſtate in bodies; and

this diſengagement ought to be reckoned among the products, and an exact account taken of it in chemical experiments, and its proportion accurately aſcertained by the proceſs of the calorimeter.

18. By noting exactly the proportion of caloric which diſappears, or combines, and that which is diſengaged and exhibited in combinations, and by comparing them together, in a great number of different operations, three reſults have been obtained, which are equally important in chemical theory. A. Caloric, like all other bodies, obeys the conſtant laws of the attraction of compoſition, and has for different bodies different degrees of relative attraction. B. Bodies in combination change their capacity for caloric; that is to ſay, after their combination they contain different quantities of caloric, ſometimes greater and ſometimes leſs than they poſſeſſed before that change. C. In every caſe, when in the change of ſtate of bodies, or their entering into combination, there is a diminution of free heat or abſorption of caloric, the quantity diminiſhed or abſorbed, will again appear without loſs, when thoſe bodies ſhall recover their former ſtate, or when the combinations ſhall be deſtroyed; and on the contrary, whenever in a change of ſtate or combination there is an increaſe of heat or diſengagement of caloric, this heat will diſappear, or the caloric will be abſorbed, as ſoon as the ſubſtances ſhall return to their firſt ſtate. By

generalizing this reſult, Lavoiſier and La Place, to whoſe labours it is due, expreſs themſelves thus: All the variations of heat, which a ſyſtem of bodies undergo in changing their ſtate, are produced in an inverſe order, when the ſyſtem returns to its firſt condition.

19. The whole of the preceding obſervations prove that caloric is not a ſimple modification of matter, that it does not conſiſt, as ſome philoſophers have thought, in a more or leſs rapid motion of the particles of bodies, but that it exiſts as a peculiar body not ponderable, very elaſtic, very compreſſible, dilatable, ſubject to the attraction of compoſition; inceſſantly entering into combinations, or ſeparating itſelf in others; ſaturating bodies after its own manner; changing their ſtate and their properties; not putting itſelf into equilibrium, except in bodies which are already ſaturated; changing their dimenſions and volume inceſſantly; itſelf poſſeſſing very variable degrees of motion or velocity, according to the impreſſions it receives, and the attraction by which it is inceſſantly agitated; diſperſed through ſpace with an immenſe liberality by nature, and performing an important part in every kind of phenomenon.

20. When caloric is in a certain reſpect developed by friction, ſo as to excite a ſtrong degree of heat, as is obſerved in ſtones, in metals, and in the woody fibres; the phenomenon conſiſts in a rapid motion, communicated to it,

which is the conſequence of its ſpring being put into action by preſſure. An idea which has been given, by comparing the emiſſion of this body to water, preſſed out of a ſponge, is very remote from the real fact, on account of the incompreſſibility of the water, which in that caſe, is the cauſe of its efflux during the compreſſion of the ſponge; whereas, in the other caſe, the caloric itſelf, which being many millions of times more compreſſible than the ſponge, recovers itſelf ſpeedily, by its ſpring, and iſſues out of bodies, of which the particles being inconſiderable, when compared with its own, imitate rather the water contained in the ſponge than the ſponge itſelf.

21. It is not neceſſary, in order to form a proper conception of the properties of caloric, that we ſhould ſuppoſe a repulſive force, which ſome modern philoſophers have imagined, unleſs the adoption of this force ſhould be conſidered as denoting the incalculable ſpring, which caloric poſſeſſes. But it is more uſeful to attend to its proper nature, and to inquire whether it differs from all other known bodies, or reſembles ſome of them; that is to ſay, in a word, to fix, with preciſion, what it is we know of the intimate nature of caloric, without tracing, in this place, all the hypotheſes which have been imagined reſpecting this part of natural philoſophy, which has long been ſubject to the ſimple power of the imagination, previous to the diſcovery of proceſſes capable of in-

forming the philoſophical world, and diſſipating the ſuppoſitions which had been univerſally admitted.

22. As long as the effects of heat were confounded under the generic term of fire, namely, its rarefaction, its motion, its light, and even the ſtill more remote or independent effects which belong to combuſtible bodies, in ſome inſtances ſuppoſed to contain, and in others, to produce fire, it has been conſtantly repreſented, or rather the imagination of philoſophers have figured this body, as compoſed of very minute and very moveable particles inceſſantly agitated, and attacking all other bodies, which, in a certain ſenſe, become its prey and its aliment. But all theſe notions are very far from being accurately applicable to caloric. When fire was imagined to be fixed or confined in bodies, and in this ſtate denominated phlogiſton by Stahl, a principle afterwards conſidered, by Macquer, as the ſame thing with light, the error was not leſs; for, in moſt caſes, caloric produces effects entirely oppoſite to that which the partiſans of Stahl have attributed to phlogiſton;—when we obſerve the illuſtrious chemiſts, Scheele and Bergmann, attributing to heat and light a very compounded nature, and admitting, even in their comparative compoſition a different proportion of the two principles which they thought they had extracted from them, or with which they imagined they had compoſed theſe ſubſtances, as I ſhall have

occaſion hereafter again to remark;—we may obſerve, as Euler did, with regard to Newton himſelf, on the ſubject of the emiſſion of light from the ſun, that there is no opinion ſo erroneous, ſo extraordinary, or even ſo abſurd, but is capable of inſinuating itſelf into the reaſonings of the moſt profound philoſophers and ſublimeſt of men.

23. But the compariſon, which the more modern philoſophers, and particularly my illuſtrious friend Monge, have eſtabliſhed between caloric and light, ſo as to conſider theſe two effects as the product of modifications of the ſame body, is entitled to much more attention. It is eſtabliſhed on a great number of experiments; it naturally and ſimply explains moſt of the phenomena; and it agrees with the ſublime economy of nature, which multiplies effects much more than the bodies which produce them.

24. In this opinion, which I muſt nevertheleſs, with its original author, preſent as an hypotheſis, becauſe it is not yet proved, with ſufficient ſtrictneſs, to be admitted among the number of preciſe facts, caloric and light are, as it were, two ſtates or modifications of the ſame body, namely, fire itſelf. In the firſt it is more divided, more ſcattered, poſſeſſes a ſlower motion, ſtrikes bodies leſs forcibly, moves them with leſs violence, and requires to be gradually accumulated, in order to produce ſenſible effects. In the ſecond it is more denſe, more active,

more rapidly agitated, it impels bodies with power, and produces a certain effect at the firſt impulſe.

Fire is diſengaged, and ſhows itſelf in the form of heat, when it is gently and ſlowly driven out of bodies into the compoſition of which it entered; but it ſhines in the form of light when it flies out of compounds, in a very compreſſed ſtate, by a ſwift motion.

25. According to this ingenious hypotheſis, caloric may become light, and light, on the other hand, may become caloric. For this purpoſe it is only neceſſary that the firſt ſhould aſſume more rapidity in its motion, and the ſecond undergo a diminution of velocity. Thus it is, that by ſtrongly compreſſing heated bodies and ſtriking them with repeated blows, they become ignited or emit light, and thus it is that in almoſt all the experiments of chemiſtry as well as in the phenomena of nature, violent heat is very near the point of inflammation, and is conſidered as the firſt degree, or the neceſſary previous circumſtance. Thus, in the chemical decompoſition, the matter of fire may diſengage itſelf under both theſe forms at once, and the proportion of light and heat which are developed, depend on the quantity of motion impreſſed on this ſubſtance, as well as the different degrees of force and energy which characteriſe the different periods of this decompoſition.

26. The individual effects which are produced either in chemiſtry or in natural philoſophy, by light and caloric, and require to be diſtinguiſhed from each other, do not form, as has been thought, any real objection againſt their identity of nature; though they may be ſufficient to induce us to treat them diſtinctly from each other, and to conſider them even as two different re-agents, becauſe in thoſe two ſtates this agent may act a different part and become a double inſtrument of analyſis, it is eaſy to explain by the different rapidity of the motion of the firſt matter which conſtitutes them, and by the varied manner in which it ſtrikes bodies, and tends to decompoſe them, all that diverſity even in the reſults which follow whether in the ſtate of light, or in the ſtate of heat.

27. By admitting this ingenious hypotheſis, we ſhall alſo find an eaſy ſolution of ſeveral phenomena which would otherwiſe remain without explanation.

In the firſt place, if caloric itſelf be not really hot, it is eaſily conceived how it may become heated by the movement, the expanſion, and ſpring which is communicated to it whenever it is compreſſed; and as it is of all bodies the moſt compreſſed, the ſmalleſt degree of preſſure, will, in fact, be ſufficient to communicate this motion. Thus it is, that by rubbing or ſtriking a ſtone, a metal, or a piece of wood, the particles of caloric lodged in their pores are compreſſed, its ſpring is rendered active, and it is made to appear in the form of ſenſible heat more or leſs intenſe.

A ſecond phenomenon equally unexplained to this time, is that which Scheele has called radiant heat. It is this ſtrong and powerful heat which is diſengaged from a ſtove, projected in all directions in rays, not deflected by the currents of air, which does not expand nor combine with it, neither does it give the vaporous ſtate to water, but is reflected by tranſparent bodies, or glaſſes, without being tranſmitted, at leaſt, with any conſiderable degree of rapidity. We here obſerve caloric in a more violent and more rapid ſtate of motion than conſtitutes ordinary heat, beginning, as it were, to aſſume the charater of light, and ſuſceptible of being reflected in the ſame manner by poliſhed metallic plates. Hence Scheele deſcribes it as having a certain reſemblance to light without being luminous, and diſtinguiſhes it carefully from heat, properly ſo called, which being combined with the air, eſcapes with it through the chimnies of furnaces.

28. The numerous and varied effects of caloric in the phenomena of nature are, in every inſtant, renewed in the proceſſes of the arts, and are more eſpecially converted to advantage by chemiſts, who make frequent uſe of them, to appreciate their juſt value, and know in what caſes to employ them, wherein it is neceſſary to determine preciſely, the general and particular mode of action of caloric on different natural

bodies. It has already been obſerved, that, by its interpoſition between the integrant particles of bodies, caloric ſeparates the particles of ſolids, and dilates them. This ſeparation cannot be made without diminiſhing the attraction of thoſe particles, and when the diminution has taken place to a certain point, the body loſes its ſolidity, becomes fluid, and the operations called fuſion, liquefaction, &c. are conſtituted, which may be conſidered as the periods at which by the introduction of caloric into bodies, its expanſive force predominates over that of the particles themſelves to the deſtruction of the ſolid ſtate. We may likewiſe conſider fuſion as a combination of the ſolid with caloric, and, on this account it is, that while any portion of a ſolid remains, which requires the abſorption of caloric in order to its fuſion, the temperature or heat will not increaſe, becauſe every additional portion of caloric becomes latent, in combination with the ſolid as it approaches it.

29. By continuing to accumulate caloric in a body already liquid, of which the pores admit a greater or leſs quantity, this compreſſed caloric combines more intimately, and perfectly with the particles of bodies and continues to ſeparate them, to diminiſh their mutual attraction, and, at length, when its proportion is become conſiderable, it completely diſſolves thoſe particles, renders them inviſible, and converts them into vapour, by imparting to them elaſtic fluidity or the ſtate of gas. The gaſes, or elaſtic

fluids, ſuch as the air we breathe, may be defined as ſolutions in caloric, which is the cauſe of their inviſibility, their rarity, compreſſibility, expanſibility; and thus it is that chemiſts employ heat to evaporate, to reduce into gas, to ſublime, and to diſtil the different ſubſtances with which their operations require theſe proceſſes reſpectively to be performed.

30. In the various operations wherein caloric may be conſidered as a true ſolvent, it exerciſes an attraction which is the more powerful on the ſubſtances it holds in ſolution; the more abundantly this principle is employed, and the laſt particles of heat which are added, compreſs and more ſtrongly attach the former particles which had been introduced. Hence it follows, that the adherence which, in this caſe, is contracted by the particles of different bodies to thoſe of caloric, proceeds ſo far as to diminiſh their attraction for thoſe of other bodies, whence it frequently happens that the gaſeous ſtate, communicated by caloric, becomes an obſtacle to the combination of bodies, and affords the means of ſeparating the principles of a compound when brought into this ſtate.

31. If, inſtead of accumulating caloric in bodies ſo as to convert them into gas, and combining them intimately with the proper particles of heat, the parts of bodies be merely ſeparated, ſo as to diminiſh the attraction of aggregation, their power of combining with other bodies becomes increaſed in the ſame proportion.

tion. Thus it is, that the application of heat is frequently ſo uſeful in laboratories, to effect ſolutions, digeſtions, infuſions, and many other ſynthetical phenomena, of which the object is to unite and combine different bodies with each other. Heat, in all theſe caſes, acts by deſtroying the aggregation of bodies.

32. Frequently when caloric is applied to compound bodies, it is found that the particles of this agent have a ſtronger attraction for ſome of the principles of the compound than that which holds the principles united together. In this caſe, the principles which are fuſible, volatile, or capable of aſſuming the ſtate of gas by caloric, obey this particular attraction, and by ſeparating themſelves from the others which are not capable of the ſame combination with caloric, they effect the decompoſition of compounds. This proceſs is very frequently ſeen in evaporation, ſublimation, roaſting, calcination, diſtillation, &c. When a few principles are thus volatilized ſeparately, and without combination with each other, by thus quitting other fixed principles alſo few in number, which likewiſe do not unite with each other; or, to ſtate the effect more ſimply, when a binary compound of a fixed and volatile body is treated by heat, the reſult of the operation is a ſimple or true decompoſition.

33. But if the caloric, applied to a complicated compound, ſhould act very differently on its principles,—if it tend to volatilize ſeveral at

the ſame time, and to favour their union in another proportion and different order; if it even permits the fixed principles to re-act ſeparately on each other, ſo as ultimately to form from an original compound ſeveral other different compounds, the effect of heat is then a complex or falſe decompoſition;—an effect which frequently takes place in analyſes by fire, in deſiccations by ſtrong heat, in calcinations for a length of time, and in deſtructive diſtillations. The ſame cauſe and the ſame reſult is alſo obſerved in thoſe ſpontaneous alterations which take place in vegetable or animal liquids in a gentle heat or moderate temperature, which are known by the names of the vinous, acid, and putrid fermentations, &c. We ſee, therefore, that the action of caloric more or leſs accumulated, is of the greateſt utility to chemiſts, and, by varying its quantity and application, we obtain a great number of different effects, and that it is with ſome appearance of reaſon that chemiſts were formerly denominated philoſophers by fire.

34. Having thus far deſcribed active caloric, or heat, as the ſource of a great number of effects, and the means of operation in many chemical proceſſes, it will not be difficult to conclude from a compariſon of all the effects, that the abſence of caloric, or a ſubtraction of that principle, muſt oppoſe every chemical attraction, all decompoſition, and alteration of compounds. Chemiſts accordingly often avail

themſelves with much advantage of this privation of caloric, in order to prevent the effect of chemical action; to impede the too powerful energy of ſolutions, combinations, and decompoſitions; to limit them to certain degrees, or to prevent thoſe ſpontaneous changes which do not fail to take place in certain compounds, if they remain for a time expoſed to a temperature ſufficiently elevated to favour the mutual action of their principles. By theſe means, namely, by a cold temperature, vegetable and animal ſubſtances are preſerved; and thus it is that the vicinity of an ice houſe, or a place in which the temperature is low and ſteady, as in certain caves and cellars, of which the heat never exceeds 10 degrees of Reaumur, are ſcarcely leſs uſeful to the chemiſt than a furnace at its different degrees of heat.

35. It has even been diſcovered, within a few years, that a conſiderable privation of caloric or depreſſion of temperature beneath that of melting ice, modifies the elective attractions ſo conſiderably that decompoſitions are produced at this temperature, which will not take place at another more elevated. This obſervation is more eſpecially applicable to the ſalts, properly ſo called, which act upon each other in a very ſingular manner, when their ſolutions are expoſed to a temperature ſeveral degrees below that at which ice melts; effects which are ſufficiently remarkable to ſhow that it will hereafter be neceſſary to add new columns to the

tables of chemical attraction, to repreſent the effects which take place below the point of congelation. And we may hence draw the inference, that chemical phenomena are very different in cold countries near the poles, or in cold ſeaſons, and in hot countries, or in the ſpring.

36. It is no leſs evident, that we ought to diſtinguiſh with care, in our deſcriptions of chemical operations, the degrees of temperature under which they are made, either by applying the thermometer, or noting certain phenomena, from which the temperature may be thermometrically deduced. Thus it was, that the ancient chemiſts diſtinguiſhed in the proceſſes of nature and art, the degrees of heat below boiling water; and accordingly, above that temperature in the firſt range, they admitted four degrees. The firſt proceeded from congelation 10 degrees; the ſecond from 10 to 20; the third from 20 to 30; and the fourth to 45 degrees, which was called the mean degree between freezing and boiling. To each of theſe degrees were attached certain phenomena, or operations to which they were favourable. The ſuperior degrees not being capable of indication by thermometric graduation, were denoted from certain known phenomena which take place at higher temperatures. The firſt degree above boiling water was that at which ſulphur melts, and in which vegetable or animal matters begin to undergo a deſtruction of their organic ſtructure.

The ſecond effect was the fuſion of ſoft metals and the moſt fuſible alloys. The third liquefied metals of middling hardneſs. And, the fourth, baked hard porcelain, and fuſed the refractory metals. Laſtly, in a degree ſuperior to all thoſe was placed the heat of the burning lens. But all theſe looſe and arbitrary graduations, not being comparable with each other, are abandoned ſince the invention of the thermometer of Wedgwood, which will be deſcribed under the article of alumine.

Article IV.

Concerning Oxigen and Oxigen Gas.

1. As the two ſimple bodies which form the ſubject of our laſt inquiry may be conſidered as the great inſtruments of analyſis and ſyntheſis, in the phenomena of nature and of art; ſince, though they approach and are probably identical in their nature, they nevertheleſs produce very different effects under each of their modifications, and conſequently require to be treated as if they were really two diſtinct bodies; ſo likewiſe will that ſubſtance, which will form the ſubject of the preſent article, though long unknown to men, and confounded with one or other of the two preceding, prove no leſs entitled to our attention than thoſe bodies, and afford to our art an inſtrument and means of

compoſition and decompoſition no leſs important and neceſſary to be known.

2. Though long concealed from chemiſts, and, as it were, eluding the ancient methods of analyſis in their poſſeſſion;—though it be an independent ſubſtance very diſtinct from every other, it is not eaſy to give a clear notion or preciſe definition of this body, becauſe it cannot be obtained alone in a ſtate of great purity, but is always obtained in combination. Nevertheleſs it can be weighed, meaſured, combined, diſengaged;—but, in all theſe caſes, it is always connected with ſome other body, which forms the ſubject of inquiry: ſo that we may affirm that its moſt permanent character is, that it poſſeſſes a very ſtrong attraction, and is itſelf attracted with great force. We are, therefore, obliged to conſider it at firſt as an abſtract being, or metaphyſical entity, when we wiſh to avoid ſpeaking of its combinations. It muſt be contemplated as one of the moſt frequent and abundant principles afforded in the analyſes of chemiſts; at the ſame time, that we muſt carefully diſtinguiſh it from what was deſignated by the term principle in the ancient chemiſtry; in which, this name was applied to ſeveral imaginary beings.

3. The term oxigen, ſignifies that which produces or generates acids. This is, in fact, one of the moſt characteriſtic properties of this body, diſcovered in Auguſt 1774 by Prieſtley. It was at firſt called dephlogiſticated air, and was after-

wards ſucceſſively known by the names of eminently-reſpirable air, pure air, vital air, as long as it was not known that this aërial form is merely one of its ſtates of combination; which, notwithſtanding its frequency and its being leſs impure in this than in any other condition, does not prevent its being concealed in other ſtates; and more particularly as, by combining with many bodies, it loſes this elaſtic ſtate or appearance of air. As ſoon as this truth was well proved, and clearly explained by Lavoiſier, the neceſſity was admitted of giving it a different name which might be applicable to all the ſtates in which it could exiſt, as well that of gas as of the liquid or ſolid form. Lavoiſier firſt called it the oxigenous principle; it was alſo named principium ſorbile on account of its eaſy abſorption by many bodies and empyreal air, becauſe it was conſidered as the principle or element of the atmoſphere, and, laſtly, the French ſchool having decided for the word oxigen, by admitting a ſimple change of termination in the firſt word propoſed by Lavoiſier, this name became generally adopted.

4. In the enumeration or claſſification of the different ſimple bodies of which the examination forms the ſecond ſection of the preſent chemical ſyſtem, I announced, that all bodies having ſome relation with the great phenomenon, known by the name of combuſtion, nothing more was required to be done than to diſpoſe them with reſpect to the effect they produce in this

phenomenon. The effect of oxigen is of ſuch importance, that its preſence muſt be ſtated as the moſt indiſpenſable condition of combuſtion; which would not otherwiſe take place. It truly conſtitutes the eſſential part of that proceſs, becauſe its moſt decided and extenſive character is its indiſpenſability in that proceſs.

5. Oxigen, like many other natural bodies, is found in three ſtates, but in neither of them is it alone or inſulated. In the gaſeous form it is diſſolved in caloric, in the liquid and ſolid form it is combined with different ſubſtances, and can never exiſt concrete and pure without combination, like many other ſubſtances no leſs decompoſable than itſelf. And though we can, in imagination, conceive it alone, inſulated, pure, and, in the ſolid ſtate, experiment has never yet exhibited this fact. It is a diſcovery which ſtill remains concealed in the boſom of nature, or may exiſt, ill underſtood, under the name of ſome ſubſtance yet unknown in our collections of minerals.

6. As oxigen is frequently contained in a more or leſs ſolid form in ſeveral natural foſſils which have undergone combuſtion, and, as it has much attraction for caloric, it is only required that ſome one of thoſe foſſils ſhould be heated more or leſs, or penetrated with a great quantity of caloric in order to diſengage this principle, and obtain it in the form of air or gas. This is done by chemiſts to procure oxigen gas. They expoſe certain ſubſtances, particu-

larly metals burned by nature, or by art, to a fire of conſiderable activity in cloſed veſſels, ſo diſpoſed as to conduct and receive, under inverted jars, the elaſtic fluid intended to be collected. The burned matter paſſes again to a combuſtible ſtate, and the oxigen which gave it the burned ſtate, being ſeparated and fuſed by caloric to which it has a great attraction, becomes developed in the form of gas. It is the product of a true combuſtion.

7. As in the operations in which oxigen is formed or obtained in the form of gas, it is obſerved, that the flame which ſhines through the veſſels, along with the caloric, contributes to the ſpeed and abundance of the diſengagement of gas, it has been concluded, that light is one of the principles of this kind of air, and that it is compoſed of oxigen, caloric, and light; but all the facts of natural philoſophy and chemiſtry, tending at preſent to prove that light and caloric are one and the ſame body, more particularly in the ſtate of combination; oxigen gas is conſidered as a ſimple combination of oxigen and caloric.

8. Of the two bodies which form oxigen gas, the caloric which is the ſolvent, and gives it the ſtate of inviſibility and elaſtic fluid, not being ponderable; the ſolidifiable baſe which is diſſolved, or oxigen, being the only ponderable and fixable body in all the ſubſtances with which this gas can combine; and chemiſts having no other means of obtaining oxigen in a

ſimpler ſtate than that of gas, in which they uſe it for a great number of operations or combinations, many of them are habituated to denote this gas by the ſimple name of oxigen. This is, nevertheleſs, an error of nomenclature, and inimical to the perſpicuity of chemical doctrine, becauſe the word oxigen ought not to be uſed but to denote the baſe of this gas conſidered alone, or in all the poſſible ſtates, but particularly in the numerous combinations wherein is poſſeſſes the liquid or ſolid ſtate.

9. Oxigen gas, prepared by the proceſs here deſcribed, poſſeſſes all the appearances of air; it is inviſible, rare, elaſtic, and fluid, and cannot be diſtinguiſhed, by mere inſpection, from the atmoſpheric fluid; but its properties are very different when comparatively examined. It is heavier than the air of the atmoſphere about ſix hundredth parts. One cubic decimetre of oxigen gas weighs very nearly 13,57 decigrams, a cubic metre 13,57 hectograms (the French inch cube being 0,50 grains and the foot cube 1 ounce, 4 gros, 8 grains). It animates the combuſtion of all combuſtible bodies; greatly increaſes flame; produces much heat in burning thoſe bodies; is totally abſorbed in combuſtion, and maintains the reſpiration of animals for a long time; elevating the temperature of their blood more ſpeedily than common air.

10. When oxigen gas is employed in any combuſtion, in the greateſt number of caſes it paſſes from the gaſeous to the ſolid ſtate. It is

precipitated from its gaſeous ſolution, and abandons its ſolvent which becomes diſengaged in the form of light and heat, whence modern chemiſtry attributes this ſecond phenomenon to that decompoſition of oxigen gas; and proves that the flame and heat ariſe from the precipitation of this gas, and the conſequent ſeparation and diſengagement of its ſolvent, and not from the combuſtible bodies as was formerly thought. Theſe laſt merely abſorb oxigen, which is liquefied or rendered ſolid in thoſe caſes by the loſs of the ſolvent which maintained it in the ſtate of elaſtic fuſion.

11. By admeaſurement of the fuſion of ice, to aſcertain the quantity of caloric, ſeparated during the precipitation of oxigen on different combuſtible bodies during the act of burning, modern chemiſts have concluded, from the difference they have obſerved, that oxigen becomes precipitated, or is fixed with more or leſs ſolidity in its different combinations; that it preſerves more or leſs of its former ſolvent, caloric, and that to this is owing the diverſity of heat formed, or of flame produced, and the adherence or difficulty of ſeparating the oxigen again from the fluid or ſolid combinations of which it conſtitutes a part. They have even conſtructed tables to repreſent the various quantities of caloric diſengaged from oxigen gas during its fixation. No modern diſcovery has given greater effect to the pneumatic doctrine than that of the different quantities of caloric diſen-

gaged from oxigen or retained by this principle fixed in combinations.

12. Theſe conſiderations have led them to diſtinguiſh and explain two kinds of combuſtion in general, the rapid and the ſlow combuſtion. In the firſt, the oxigen gas ſpeedily loſes the greateſt part of its caloric which then forms heat and flame; in the ſecond, it is ſeparated ſlowly, and ſometimes in a ſcarcely perceptible form, in which caſe it is ſcarcely poſſible to appreciate the caloric developed. The reſult of the firſt with regard to oxigen is, that the bodies which abſorb it continue in the ſolid ſtate, and almoſt entirely deprive it of its ſolvent; at the ſame time that it adheres ſo ſtrongly as to be very difficult to ſeparate. The reſult of the ſecond, on the contrary, is, that the bodies in which it is precipitated do not retain it but in a ſlightly ſolid ſtate, little altered, and eaſy to be diſengaged. The firſt claſs of bodies are very difficult to unburn, and the latter are eaſily deprived of this principle. The former when expoſed to light, almoſt alone, or aſſiſted only by a ſimple quantity of caloric, ſuffer the oxigen gas to eſcape, and themſelves return to the combuſtible ſtate; the others require to be penetrated with a great quantity of caloric and light in order to looſe their oxigen.

13. All combuſtible bodies abſorb different quantities of oxigen in burning. They may be converted to different ſtates of burned bodies, according to the proportion of oxigen they have

abſorbed. They abſorb it in a more or leſs ſolid ſtate, or more or leſs ſeparated from its ſolvent, even in the different proportions they abſorb, and they attract this principle not only with different energies, but differently as to the ſeveral quantities they contain. The law of attraction, in the inverſe ratio of the ſaturation, takes place here as well as in all the other kinds of combinations.

14. As the attractions of oxigen vary in each different body, it follows that by preſenting a compound which contains it, to a body which has a ſtronger attraction for this principle than the firſt body to which it is united, it will paſs from the compound to the ſecond body; and as it ſeldom happens that this ſecond body with which it may combine, abſorbs or retains it in the ſame ſtate of ſolidity equally deprived of part of its ſolvent, it is a conſequence that when without quitting the ſtate of ſolidity or fluidity, it paſſes from one body to another, the mixture is in ſome inſtances heated, namely, when the oxigen abſorbed is rendered more ſolid, or, on the contrary, a diminution of temperature takes place, if the body which attracts it cannot hold it in the ſame ſtate of denſity. The firſt of theſe two caſes is accompanied with a riſe of temperature even to inflammation, which takes place when the difference of ſolidity acquired by oxigen in paſſing from one body to another, demands a ſtrong and ſpeedy ſeparation of caloric.

15. As it is impoſſible to know and deſcribe the properties of pure oxigen, becauſe nature has not yet preſented it to man in this ſtate, and becauſe art has hitherto diſcovered no means of diſengaging it; no method of characterizing this ſubſtance remains but to determine the properties of oxigen gas, or oxigen diſſolved in caloric, and thoſe properties which are produced in bodies by an union with oxigen in the liquid and ſolid ſtate. We have already ſeen, in what has been explained reſpecting oxigen gas, that it is well characterized by the excluſive property of maintaining combuſtion, and the reſpiration of animals, in which, to the laſt particle or bubble in its gaſeous ſtate, it operates as the ſource of caloric and light diſengaged in thoſe operations. Its ſpecific gravity has likewiſe been ſtated as a circumſtance which eaſily aſcertains its place among aëriform bodies.

16. With regard to the properties produced by oxigen, when it becomes fixed in the liquid or ſolid ſtate, in the different bodies to which it has an attraction, it is very evident, that the new properties acquired by compounds, in conſequence of the fixation of this principle, which they did not before poſſeſs, and which they loſe when the oxigen is ſeparated, may be conſidered as belonging to this laſt ſubſtance, or, at leaſt, as produced by its preſence, and proper to deſignate its character, until it can be examined alone and in a ſtate of purity. Now among thoſe properties one of the moſt conſtant is, to

communicate more or leſs taſte to bodies which before were taſteleſs, or to augment the ſapidity of bodies which are already ſapid. So that though we may not be juſtified in affirming that oxigen is the ſole cauſe of taſte, we muſt, nevertheleſs, conſider it as ſuch in a great degree in all bodies with which it combines.

17. This taſte which it communicates to bodies is frequently ſour, and it often, in fact, conſtitutes the acid nature in ſubſtances with which it combines. It is, therefore, at the ſame time, in ſuch bodies, the ſource of all the properties which characteriſe the acids, and, as this circumſtance is one of the moſt frequent and moſt remarkable of thoſe which accompany its combinations, it has hence obtained the name of oxigen.

18. The ſecond property communicated to bodies by the addition of ſolid oxigen is colour. It is this ſubſtance which, in fact, colours all the burned metals, and gives the tints ſo various, ſo brilliant, and ſo durable which are poſſeſſed by enamels and glaſſes of every ſhade. Though this character is very decided with reſpect to various oxigenated compounds, when we compare it with that of taſte, it is found to be leſs conſtant and leſs general. There are, in fact, a conſiderable number of compounds in which oxigen, though in a large proportion, communicates no colour or tint, but rather makes them tranſparent.

19. It is uſeful to obſerve in this place, that the many vegetable colouring matters owe the different ſtate of their colours to the varied proportion of oxigen; we muſt, nevertheleſs, reckon among its properties that it tends to diſcolour organized ſubſtances, and that when it is accumulated it renders them white. Such is the ſource of moſt of the methods of bleaching, and more particularly that of cottons, linens, and wax, by expoſure to the air, as will be fully explained in the other ſections of this work.

20. We muſt more particularly claſs, among the diſtinctive and characteriſtic properties of the combinations of oxigen that denſity, coagulation or concretion in general which it produces in organized bodies. It is to this phenomenon, well determined, that ſeveral effects of vegetation and of animalization are owing, which will be ſhown in the ſection appropriated to their hiſtory. It is here noted, merely to bring together the principal properties communicated by oxigen. It will alſo be ſeen, that the accumulation of oxigen in organic ſubſtances, operates their complete decompoſition.

21. From the taſte produced by oxigen, follows a very remarkable property of the ſubſtances thus acted upon, namely, the medicinal power of ſome, and the cauſtic or poiſonous acridity of others. The firſt is the minimum of the ſecond, and accordingly we find in the medicinal action a great number of degrees; and

poiſons, of which the energy is ſimply moderated, are frequently employed as remedies. In the terrible action of cauſtics, oxigen evidently quits thoſe bodies to act on the animal organs which it burns and deſtroys.

22. By confining the preſent examination of oxigen to the enunciation of thoſe general properties, it is ſufficient, in the mean time, to ſhew how extended and important its action and influence muſt prove in all the phenomena of nature and of art. The mere exhibition of this principle ſhows that it is one of the moſt energetic and moſt powerful agents that chemiſts can employ. It is an inſtrument applicable to a number of operations, and which is inceſſantly effective in chemical proceſſes; conſequently its properties, its attractions, its different ſtates, its tranſitions, from one ſyſtem of bodies to another, conſtitute almoſt the whole of the modern pneumatic doctrine. They have rendered the theory of chemiſtry much more general, more clear, and more ſimple, than it was before the diſcovery and knowledge of this principle. It has truly changed the face of the ſcience.

23. Every fact tends to prove that oxigen is one of thoſe ſimple bodies which nature employs moſt frequently in all combinations and decompoſitions; which is found moſt abundantly diffuſed among all her productions, and conſtituted in the atmoſphere of our globe reſervoir, as we ſhall ſee in the following article.

ARTICLE V.

Concerning the Air of the Atmoſphere.

1. THAT elaſtic fluid, which fills and conſtitutes the atmoſphere, is very far from being a ſimple or undecompoſed ſubſtance, a real element, as was, for a long time, ſuppoſed by philoſophers and chemiſts. It ought not, therefore, ſtrictly to belong to the ſection of ſimple bodies; but as the greateſt number of its known effects evidently depend upon the principle which has formed the ſubject of the preceding article, which is one of the conſtituent ſubſtances of the atmoſphere, its hiſtory can only be placed at the end of that of the laſt-mentioned body; ſince this laſt can alone throw the greateſt light upon its properties and chemical characters.

2. The atmoſpheric air being the only natural body which is conſtantly in the elaſtic fluid form, which encompaſſes the globe, and in which it is continually immerſed, and this form rendering it the common receptacle, as well as cauſe, of a great number of natural phenomena, which it is neceſſary well to underſtand, we cannot diſpenſe with ſtudying it in its grand maſs, by conſidering it at firſt collectively, and deſcribing the influence of its phyſical or general properties, its gravity, fluidity,

ſluidity, &c. the compoſition or decompoſition of the other bodies, which it touches, covers, preſſes upon, agitates, and inceſſantly changes.

3. By the name of the atmoſphere, we underſtand the entire maſs of the air which encircles all parts of the terreſtrial globe, which moves with it, which touches it in all parts, aſcending to the tops of its mountains, penetrating into its cavities, inceſſantly floating on the ſurface of its waters, and in the midſt of which all the beings detached from the maſs of the globe, plunge, move, or are carried off. It is a vaſt ocean, compoſed of all that is capable of being volatilized from the earth, of all that can be reduced to vapour at the various degrees of temperature and preſſure, containing an aſſemblage of mineral, vegetable, and animal matters, which repreſents a ſort of chaos, and which, conſidered in this point of view, muſt preſent continual and almoſt indeterminable variations, though chemical analyſis has attained to the diſtinction of the conſtant terms of its compoſition, as will be ſeen hereafter; becauſe the various ſubſtances which are capable of being ſuſpended in it are, in fact, only accidental, with reſpect to its intimate nature, which they never change.

4. It is not known, with preciſion, to what height the air of the atmoſphere extends, or what is the real dimenſion of the atmoſphere; but we know that its different ſtrata are more

denſe and compreſſed, the nearer they are to the globe, and that their variation, at a great elevation, is limited, in conſequence of the colder temperature of the upper regions. It is alſo known that, in the elevated regions, luminaries and inflammable meteors are generated; that the atmoſphere is croſſed in every direction by light, and with more difficulty by caloric, of which it is a feeble conductor; that it alſo confines the electric fluid; that the upper clouds are more ſtrongly electrified than the lower ones; that the lightning conſiſts of a ſudden communication or diviſion of the electric fluid between the lower clouds and the terreſtrial globe; and that it is by riſing to different heights in the atmoſphere, by the aid of aeroſtatic machines, that natural philoſophers will become better acquainted with the cauſes and effects of meteors.

5. The elaſtic fluidity of the atmoſpheric air, which cannot be deſtroyed, by any preſſure, or known degree of cold, explains the facility and rapidity of its motions; among which thoſe which are conſtant, and occaſioned by the preſſure of the ſun and moon, are almoſt incapable of eſtimate or meaſure, in the midſt of much greater agitations, produced by accidental and variable cauſes. Such is the general motion of the winds, the moſt rapid of which proceed, at leaſt, twenty metres, (or yards nearly) in a ſecond; and thoſe which are more common, poſſeſs a velocity only equal to one-third

of the former. It is farther remarkable, that notwithſtanding this extreme fluidity, of the air, it cannot paſs through a number of bodies which are permeated by water and other liquids. It muſt not however be forgotten that this fluidity, and the quickneſs of motion it admits of, are very ſmall in compariſon with that of light, which appears to communicate theſe properties to the air, as will ſpeedily be ſhown.

6. The diſtance between the integrant particles of the air admitting of the paſſage of light, this fluid, in ſmall maſſes, is really inviſible, or the moſt tranſparent of all bodies. But when large maſſes are obſerved, the deviation and reflection of the luminous rays render this air more or leſs viſible, and even give it a blue tinge. This colour has been erroneouſly attributed to the heaven itſelf, and denominated ſky blue; it is only the ſeries of atmoſpheric ſtrata, amaſſed at no great diſtance from the earth, that we perceive under this colour; and there is an immenſe diſtance between theſe ſtrata and the region of the ſtars.

7. The atmoſpheric air is generally conſidered as inſipid. This proceeds only from the long habits of mankind to reſpire and feel it, as is proved by the cries of a child, the firſt time it is ſubject to its impreſſion, when brought into the world; the acute pain excited by its contact with wounds, cuts, and on our organs, when deprived of the epidermis; the difficulty of cicatrization in wounds, even of vegetables, when

the air inceſſantly touches them; the lively impreſſion it produces on nerves in general when uncovered, and the caries cauſed by it in bones deprived of the perioſteum.

8. The gravity of common air, and all the phenomena which depend upon the weight and preſſure of the atmoſphere, unknown to the ancients, have changed the face of natural philoſophy ſince the middle of the ſixteenth century, in conſequence of the important thought of Torricelli, and the exact experiments of Paſcal and Perrier, made by the latter on the mountain *Puy de Dome*, in the month of September 1643. It is this gravity which ſuſtains water, at more than ten metres or thirty-two French feet, in pumps; and mercury at little more than three-fourths of a metre, or twenty-eight French inches in a tube of glaſs. It is this which gave riſe to the invention of the barometer, the height of which, is the exact meaſure of the weight of the atmoſpheric air, if a ſlight correction be made for the variation of its temperature. By means of this corrected barometrical meaſure it is that the height of mountains, the depth of mines, &c. may be eſtimated with preciſion. The cube decimetre of air weighs twelve and one third decigrams, and the cubic metre twelve and one third hectograms. (The cubic French inch 0,46 of a grain, the cubic foot one ounce, three drams, three grains.)

9. This weight, eſtimated by the methods of experimental philoſophy, and which per-

fectly explains the variouſly compreſſed ſtate of the different ſtrata of atmoſpheric air, has alſo, by the preſſure it exerts, an influence upon the ſtate of ſolids and liquids; it is to this preſſure, that the permanence of liquids at the ſurface of the globe may be accounted for, as it prevents their rarefaction. It is neceſſary to overcome it, to reduce liquids to a ſtate of vapour, as well as to form the gaſeous bodies. It ought, therefore, to be well underſtood and accurately eſtimated, and chemiſts are continually under the neceſſity of attending to barometrical obſervations.

10. Compreſſibility and elaſticity are two properties equally inherent in common air; they are the ſource of a number of natural phenomena, as likewiſe of many effects that are produced in philoſophy and the arts. The fracture of veſſels the ſuſpenſion of liquids, the obſtacles to their dilation and evaporation, the detonations, are of ſuch importance in chemiſtry, that all machines founded on theſe properties are requiſite to be known, and uſed in philoſophical experiments. As by analogy and compariſon with air, a judgment is often formed of the bulk and quantities of different gaſes obtained or employed in chemical operations, it becomes indiſpenſable to determine with accuracy, the ſeveral ſtates of preſſure of theſe fluids.

11. The property of occupying a large bulk, the power of expanſion or rarefaction, the con-

ſequence of the ſpring of the air, which it is found to aſſume, either by the accumulation of caloric, or by the diminution of preſſure, is alſo one of thoſe properties which have the greateſt influence in chemical operations. It regulates, in fact, the ſpring and denſity of all the other elaſtic fluids that are obtained in the experiments of chemiſtry; but the common air is ſo often admitted into chemical veſſels, that it is from this fluid that the phenomena of rupture and exploſion moſt frequently derive their origin; and, under this point of view, it highly deſerves the attention of chemiſts.

12. To all the phyſical properties which have hitherto been conſidered in air, the chemiſt muſt add the knowledge of thoſe which it preſents by its attractions, by the combinations of which it is ſuſceptible, by the decompoſitions it is capable of effecting, in ſhort by the effects it produces, either by uniting with other bodies, or by being diſengaged from the combinations which contain it. There is ſo great a diſtance between the inaccurate and looſe notions which were formerly entertained upon this ſubject, and the preciſe ideas acquired by modern diſcoveries, that the appearance of the ſcience has become totally changed. Before theſe diſcoveries, chemiſts were contented with claſſing air among the number of the elements; and conſidering it as one of the conſtituent principles of bodies. Boyle and Hales added, that it was fixed in bodies; that it was diſengaged from them dur-

ing their decompoſition, and that it might be collected by eſtimating the quantity and ranging it the number of the products. Nevertheleſs, Mayow, a cotemporary of Boyle, ſuſpected that only a certain part of the air became fixed in bodies: but this firſt ſuſpicion, which might alſo have been found in the works of Paracelſus and Van Helmont, was merely an hypotheſis before the experiments of Lavoiſier upon air, which were no leſs new than preciſe and ingenious.

13. From the numerous inquires of Lavoiſier, which have ſince been repeated and confirmed by all chemiſts, it appears that the elaſtic fluid, treated of in the preceding article under the name of oxigen gas, compoſes an eſſential part of the air; that it is capable of maintaining combuſtion and reſpiration, by virtue of its proportion of that ſubſtance; that theſe two characters, which had been excluſively attributed to it before the diſcovery of vital air or oxigen gas, which poſſeſſes them with much greater energy, are entirely owing to a part of this gas which it conſtantly contains, and that when it is deprived of it, theſe properties are no longer to be found. Hence, on examining in the preceding article, the properties of oxigen in a ſtate of gas, the examination of air was commenced, and exact notions were acquired reſpecting thoſe conſtituent principles which beſt characteriſe it.

Nothing more is neceſſary than to know how this oxigen gas is modified in the air, and how, in conſequence of theſe modifications, the phyſical and chemical properties of common air differ from thoſe of pure oxigen gas.

14. There is no one who, on comparing by a ſimple and eaſy experiment, the manner in which a combuſtible body burns in air, with the manner in which it burns in oxigen gas, will not immediately diſcover that the activity, the quickneſs, the heat produced, and the flame diſengaged in this laſt combuſtion; are much ſuperior to thoſe which accompany the former. Every obſerver is ſtruck with this difference, and to a perſon the leaſt attentive, and poſſeſſed merely of curioſity, it affords a brilliant ſpectacle, which prevents him from confounding in any manner the phenomena produced by air, with thoſe which are produced by oxigen gas.

15. On obſerving with more care, that is to ſay all the reſults, the ſtriking diverſity of this phenomenon of combuſtion, philoſophers and chemiſts have been able to prove that atmoſpheric air of a given bulk, or ſtill more preciſely of a given weight, burns only one-third part of the ſame combuſtible body that is burned by oxigen gas, and that, while the latter is entirely abſorbed even to the laſt bubble, by matters ſuſceptible of rendering it ſolid, the atmoſpheric air, on the contrary, loſes little more than one fifth part of its bulk; that there is conſequently only a certain part of its maſs

which is capable of combining with combuſtible bodies, of ſupporting their combuſtion, as well as ſerving for the reſpiration of animals.

16. This obſervation very naturally led them to explain why combuſtible bodies would not burn in a vacuum, why they were extinguiſhed after ſome time in air that was not renewed, why common air was diminiſhed in bulk, why thoſe ſubſtances which burn in it are increaſed in weight; how this augmentation of weight was exactly in proportion to the loſs of air: for it was ſoon proved that the diminution of bulk in the air was neither the effect of ſimple preſſure, nor deſtruction of its elaſticity, as had long been imagined, nor the effect of a combination with ſome matter diſengaged from combuſtible bodies which would have confined or condenſed its particles. It was not more difficult to comprehend why the air in which a combuſtible body was extinguiſhed after having been burned, again extinguiſhed another lighted body immerſed in it, or why it ſuddenly killed animals: it was found that ſuch air had been deprived of its aliment of combuſtion.

17. But as common air could not entirely conſtitute the aliment of flame, like oxigen gas, it was neceſſary to aſcertain whether the property of maintaining combuſtion really proceeded from this oxigen gas, and whether the limits of its power, with reſpect to this phenomenon, were fixed by the quantity which it contained. Lavoiſier directly proved both theſe propoſitions;

he ſhowed that they were demonſtrable facts, by proving, firſt, that bodies burned in common air afforded alone, and without any addition except caloric and light, oxigen gas exactly in the ſame proportion as that which they had derived from the air while burning in it; and ſecondly, that this portion of oxigen gas, ſeparated from a burned body, and added to the reſiduum of the air which had ſerved for combuſtion, entirely re-compoſed common air, and gave to the reſidue the property of ſerving, as before, for combuſtion, in the ſame manner, and during the ſame time.

18. Thus, as ſoon as air, exactly ſimilar to that of the atmoſphere, was again formed, by mixing with the air already uſed, or exhauſted by combuſtion, a portion of oxigen gas before precipitated from the atmoſpheric air in a burned body, equal to that which it loſt;—ſince a real ſyntheſis of common air was thus effected, it is very natural to conclude that the analyſis of common air was truly made by combuſtible bodies; that the latter, immerſed in air, gradually abſorb its oxigen, and ſeparate a certain quantity of its ſolvent caloric; that they are only capable of taking this principle, which is alone ſuſceptible of making them burn; that they do not in any manner affect that portion which is not oxigen gas, and that the elaſtic fluid which remains after combuſtion being a mephitic gas, extinguiſhing burning bodies and killing animals, it may be concluded, with Lavoiſier,

voiſier, that common air is really a compound of two gaſes, oppoſite in their nature with reſpect to combuſtion and reſpiration.

19. Twenty-ſeven parts of oxigen gas, and ſeventy-three parts of a mephitic gas, not abſorbable by combuſtible bodies, and not capable of aſſiſting their combuſtion, therefore compoſe the atmoſpheric air under the moſt uſual circumſtances. It cannot be ſaid that the mephitic gas is formed by the effect of combuſtion, and that conſequently air is a ſimple ſubſtance, identical in its conſtituent particles; for common air can be formed originally, by mixing, in the proportions above-mentioned; oxigen gas, and the kind of mephitic gas which is thus formed, after having obtained both, from ſubſtances foreign to the atmoſphere, are, in reality, very different from each other, as will be proved in the following article, where we ſhall treat of the nature of this mephitic gas of the air, which cannot be formed by combuſtible bodies, during their combuſtion.

20. As combuſtible matters effect, during their combuſtion, a real analyſis of the air, it has been concluded, that if the latter ſhould vary in the proportions of its two principles, theſe variations might be eſtimated with accuracy; and hence originated eudiometry, or the art of diſcovering the purity of air by inſtruments called eudiometers; the mechaniſm and general diſpoſition of which, are ſuch, that they contain well-meaſured quantities of air, and in-

dicate with preciſion how much of this meaſured air contributes to combuſtion, as alſo what reſiduum it leaves after the combuſtion is over. To be well acquainted with the uſe of this inſtrument, it muſt be known that all combuſtible bodies do not carry off entirely, by the firſt action, and by a ſingle operation, all the oxigen gas of the air; that ſome abſorb more than others; that, in this reſpect, a choice ſhould be made between them, and according to that choice, each eudiometrical proceſs ought to be treated in particular under the article of each combuſtible body, which we ſhall take care to perform. It is only neceſſary to ſtate here, that, by modern eudiometrical proceſſes, and particularly by the important reſearches of M. Humboldt, we have learned that the proportions of the two aërial fluids may vary to ſuch a degree, that the oxigen gas may conſtitute from 0,23 to 0,29 parts.

21. Each combuſtible body not only has a different capacity for fixing or conſuming atmoſpheric oxigen gas, by which they all differ in their eudiometrical uſes; but alſo, on comparing theſe bodies together, a general difference is found to exiſt between them, which muſt cauſe their utility to vary conſiderably with reſpect to the analyſis of air. If, in ſhort, the greateſt number have the property of abſorbing oxigen, more or leſs ſolid, and conſequently of diminiſhing the volume of air, there are alſo others which melt in oxigen gas, while

themſelves loſe their ſolid ſtate,—which diſappear, and do not all, or but in a very ſmall degree, diminiſh the bulk of the air. It is thus that on burning tallow, candles, wax, or wax candles, oils, alcohol, ether, and carbonaceous ſubſtances in general, in a certain quantity of atmoſpheric air, this elaſtic fluid experiences very little diminution in its bulk, and conſequently we cannot form an opinion of its quantity or nature from ſuch diminution. This circumſtance will be explained at greater length in ſeveral of the ſubſequent articles.

22. Although the analyſis of air, and an exact knowledge of the proportion of its two gaſeous principles be eſſential in many chemical operations, it is proved that the hopes, which had at firſt been entertained, as to the utility of eudiometrical reſults in medicine are ſtill only illuſive, and that the effects of atmoſpheric air as the cauſe of diſeaſes, are not to be attributed to this proportion, but to cauſes yet unknown, or not hitherto aſcertained by our phyſical and chemical means. Various miaſmata, that is to ſay very fine particles, alſo foreign to the two gaſes which conſtitute the maſs of the air, may be ſuſpended, diſſolved, and tranſported, ſo as to produce, in the liquids or ſolids of animals who reſpire it, diſeaſes or alterations more or leſs conſiderable. The eudiometrical proceſſes detect none of theſe, and throw no light upon their nature, their difference, their quantity, or action.

23. It is the ſame with a number of foreign ſubſtances in the two conſtituent gaſes of the atmoſphere, which can only be eſtimated with difficulty, and by methods of approximation foreign to the eudiometer, ſuch as the electric fluid, the magnetic fluid, light, caloric, vegetable, animal, or mineral powders, which flutter from all parts in the air of the atmoſphere, and which inceſſantly cauſe a variation in its quantity and nature. The ſame obſervations muſt neceſſarily be applied to water itſelf, the proportion of which can be meaſured between certain limits in the air, but the real quantity of which cannot exactly be aſcertained; becauſe we have no fixed term to proceed from.

24. We may add to this, that, in the atmoſphere, there is conſtantly found a ſmall quantity of volatile and gaſeous acid, known by the name of carbonic acid, which will be treated of at length in the third ſection of this work. It is in the proportion of 0,01 to 0,02; and notwithſtanding the ſmallneſs of the quantity, it is ſufficient, in conſequence of the air which is ſo often renewed at the ſurface of bodies, to cauſe a number of effects and phenomena which will be appreciated in proportion as our chemical courſe ſhall be diſcloſed in the following articles.

25. The atmoſpheric air ſerving for combuſtion and reſpiration only in conſequence of the 0,27 parts of oxigen gas it contains, and the ſpecies of mephitic gas which forms 0,73 parts of its compoſition, and which will be inveſti-

gated in the following article, under the name of azote gas, not contributing in any manner to theſe phenomena,—Lavoiſier has repreſented the latter as a paſſive principle, and the firſt only has been obſerved in ſome degree as the cauſe of all the chemical properties of the air. It is neceſſary however to obſerve, in this reſpect, that if the azote gas were really a paſſive principle in combuſtion, as this illuſtrious chemiſt would inſinuate, doubtleſs, with the intention of rendering his beautiful theory more clear and intelligible, the atmoſpheric oxigen would burn bodies with an activity and quickneſs equal to that of the former gas; and it is a well-known fact that this effect does not thus take place, and that there is a great difference between the manner of burning in atmoſpheric air and in pure oxigen gas. The ſame effect is ſeen with an artificial mixture of this gas in the proportion of 0,27, with azote gas in the proportion of 0,73, or with the real factitious air of modern chemiſts. In this factitious air, oxigen gas loſes, by the addition of azote gas in the proportion indicated, its property of burning the combuſtible bodies with the activity and brilliancy which it gives to their combuſtion when it is pure; and it cannot be doubted, but that this modification is produced by the addition of azote gas. It appears that when theſe two gaſes are mixed, they penetrate and approach each other; for the ſpecific gravity of the mixture is rather more conſiderable than the mean term of that of the two gaſes; that they are condenſed; that a combination is in ſome degree commenced between them; and that the oxigen gas being enveloped and as it were latent in nearly three parts of azote gas, cannot then re-act upon combuſtible bodies, the ſame as when it is alone: theſe bodies are, therefore, obliged to withdraw it from this kind of combination, and to employ for this ſpecies of attraction, an effort which will retard their union with oxigen, and diminiſh the energy of their combuſtion, either in the quickneſs or activity of the phenomena which accompany it. It is, therefore, the ſame with the oxigen gas lodged between the particles of azote gas, as with a ſalt, an acid, or alcohol, diſſolved and diluted in water: their properties remain the ſame; but their taſte, and their tendency to combination are diminiſhed or weakened by the interpoſition of the watery particles between their own particles.

26. All theſe chemical facts relative to the properties of atmoſpheric air, which have been acquired by the reſearches of the moderns, and have produced many happy alterations in the theory of the ſcience, afford innumerable applications to the different branches of chemiſtry that have been pointed out in the firſt ſection of this work. There is ſcarcely any department which does not derive ſome important and uſeful information from theſe diſcoveries. Among theſe in particular, are meteorological chemiſtry, which relates to the knowledge of various mo-

difications or phenomena in the atmoſphere; mineral chemiſtry, regarding the changes which take place in foſſils by the contact of air; medicinal or domeſtic chemiſtry, for the choice, the correction, and purity of this fluid; vegetable and animal chemiſtry, relative to the influence of air upon vegetation and animalization; and laſtly, manufacturing and pharmacological chemiſtry, for the action of its contact more or leſs enlarged or in other inſtances kept off and prevented in the preparation of a great number of products of the arts and of medicine. A great number of examples of theſe multiplied applications will be given as we proceed.

ARTICLE VI.

Concerning Azote and Azote Gas.

1. AZOTE is a ſimple body in the ſame condition with regard to us as oxigen; it cannot be obtained in a ſtate of purity. It is always either fuſed in caloric in the form of gas, when it has the name of azote gas; or liquid and ſolid in certain natural and artificial compounds. If it exiſts alone, either in the ſolid or liquid form, in nature, it has hitherto eluded the reſearches of chemiſts.

2. Like oxigen, azote remained for a long time unknown: its diſcovery has not even been

a direct conſequence of that of moſt of the other elaſtic fluids. The moſt celebrated foreign philoſophers long confounded it with exhauſted air, changed air, or rather have for a long time believed that it was only air infected by phlogiſton, becauſe they knew and examined it only in the reſidue of common air which had ſerved for combuſtion and reſpiration; and becauſe they ſuppoſed it to be the conſtant product of this alteration of the air, and that this alteration conſiſted in a ſurcharge of an imaginary principle named phlogiſton, they for a long time denominated this ſubſtance, which they only knew in the gaſeous ſtate, phlogiſticated air.

3. Lavoiſier is the firſt chemiſt who imagined and proved, by his accurate experiments on combuſtion, that azotic gas is contained, or exiſts ready formed in atmoſpheric air; that combuſtible bodies contribute nothing to its formation; that they only ſet it free, or inſulate it, or ſeparate it, by abſorbing the oxigen and diminiſhing the volume of common air; that it is entitled to a peculiar name, diſtinct from all the other elaſtic fluids. To diſtinguiſh it accurately inſtead of confounding it with the other mephitic gaſes, and particularly with the carbonic acid, which has long been diſtinguiſhed by that name under the gaſeous form, Lavoiſier firſt called it atmoſpheric mofette, or mephites, after the Italian word given to dele-

terious gaſes, which are diſengaged from the earth, and collected in its cavities.

4. Citizen Berthollet afterward ſhowed that the baſe of this gas enters into the combination of many ſolid and liquid ſubſtances. M. Cavendiſh diſcovered it in an acid very frequently uſed, and which will ſoon be treated of. I have myſelf made a very conſiderable ſeries of reſearches concerning the combinations of this principle, and its diſengagement during the combuſtion of the different ſubſtances which contain it. In conſequence of all theſe inveſtigations, the French chemiſts, perceiving the neceſſity of claſſing this ſubſtance among thoſe which nature employs in many of her compounds, and of ſtudying its properties and attractions with care, have diſtinguiſhed it by the name of azote. Some foreign chemiſts have propoſed to give to it the name of *ſepton:* it will be ſeen on what foundation this laſt propoſition is grounded.

5. Nature, has without doubt, placed azote among its elements, or the primitive ſubſtances moſt uſeful to her views and phenomena, becauſe ſhe has expanded ſo great a quantity of it on the ſurface of the globe, and becauſe ſhe has formed of it 0,73 of the atmoſphere of the earth. Common air containing almoſt three times as much azote in the ſtate of gas as of oxigen under the ſame form, there is reaſon to believe that it is of uſe in very multiplied and very important purpoſes; and that chemiſtry is yet

very far from having determined the whole of them.

6. Since azotic gas is contained ready formed, and in very great abundance in atmoſpheric air, it is evident that all the proceſſes of chemiſtry, by which oxigen is abſorbed by cauſing it to loſe the form of gas, may ſerve to obtain azotic gas, provided they completely ſeparate from it the principle of combuſtion. But though the means of inſulating azotic gas are very multiplied in theory, becauſe all the combuſtible bodies and all the reſpiring animals appear to accompliſh this purpoſe; yet ſince the greater number of theſe bodies either do not carry off the laſt proportions of oxigen, or are completely, or in part, fuſed in gaſeous oxigen, the number of combuſtibles which are of uſe ſucceſsfully to inſulate and enable us to obtain azotic gas ſeparate, is very inconſiderable.

7. According to the proceſs of Lavoiſier, the pyrophorus, a ſpecies of combuſtible ſulphurated carbonaceous product, which will be ſpoken of more fully in another ſection, is uſeful for obtaining atmoſpheric azotic gas by abſorbing all the oxigen; but it forms a gaſeous acid, which muſt be carried off before the azotic gas can be had very pure. If it were poſſible to burn phoſphorus, or a metal in the air, without extraordinary care and expence, very pure azotic gas might be thus procured; becauſe theſe ſimple combuſtibles fix all the oxigen; but

theſe proceſſes, being attended with much loſs, and being too tedious and delicate for practice, cannot be employed with advantage.

8. Scheele has made a diſcovery relative to the art of obtaining pure azotic gas, of which he himſelf did not know the full value: in the hands of the French chemiſts, it has become one of the beſt proceſſes for obtaining that product. A ſpecies of combuſtible preparation which will be deſcribed, in one of the following articles, under the name of earthy or alkaline ſulphuret, is diſſolved in water; with this ſolution the eighth part of a great flaſk, or bottle of the capacity of ſeveral litres is filled; the reſt is full of air; the veſſel is well corked, and reverſed; the opening at the bottom is plunged into another veſſel full of water, in order to intercept all communication with the atmoſphere. After ſome days, the ſulphurated ſolution is found to have abſorbed all the oxigen of the air. If the flaſk be uncorked under the water, this fluid aſcends and replaces the abſorbed oxigen; it is found that about the fifth of the volume of the gas has diſappeared; the reſidue of the gas is then well waſhed by agitating pure water in the veſſel, and this reſidue is the pure azote gas.

9. Citizen Berthollet has diſcovered a ſhorter and ſimpler proceſs to procure this gas, which is abundantly contained in the fleſh of animals: he diſengages it, by treating this ſubſtance with weak nitric acid in a ſuitable apparatus. A conſiderable quantity of azotic gas is obtained

by this means: I have ſince diſcovered that it exiſts pure in the natatory veſſels of the carp. It is ſufficient, therefore, when a great number of theſe veſſels can be procured, which is not difficult in the fiſh markets, to break this membrane in the pneumato-chemical apparatus under veſſels filled with water; the azotic gas eſcapes, riſes, and is collected in the upper part of the veſſels. In whatever manner azote gas is obtained, if it be well prepared, it poſſeſſes, in every inſtance, conſtant and characteriſtic properties.

10. Azote gas, the neareſt poſſible to the ſtate of purity in which azote can be ſuppoſed, becauſe it is only combined with caloric, has all the apparent properties of atmoſpheric air; it has an inſipid animal-like ſmell; it has no ſenſible taſte; its weight is a little leſs than that of atmoſpheric air; it weighs nearly one hundredth and a half leſs than that fluid. The decimetre cube of this gas weighs nearly 11,90 decigrams, and the cubic metre nearly 11,90 hectograms (the cubic inch of France, a little more than 0,44 of a grain; the cubic foot, one ounce, two gros, forty-three grains, according to Lavoiſier). It is for this reaſon that, of two lighted tapers in a receiver full of air, the moſt elevated is firſt extinguiſhed.

11. When an inflamed, or burning body, is plunged into azote gas, the combuſtion is quickly ſtopped, and the inflamed body is extinguiſhed as if in water; an animal is no leſs ra-

pidly deprived of life. If neither of theſe remain in this deleterious gas till it has loſt a certain elevation of temperature, the one is again kindled with exploſion, and the other is ſuddenly recalled to life, by placing them in oxigen gas. Azotic gas being neither combuſtible nor reſpirable in its own nature, is therefore oppoſed, under this point of view, to oxigen gas. That ſubſtance was formerly named vital air, this by oppoſition was named at firſt azote gas.

12. No ſubſtance yet known poſſeſſes the property of fixing, or precipitating from its ſolvent, azote in the ſtate of gas; at leaſt this property has not yet been diſcovered in any ſubſtance. It is for this reaſon that chemiſts can make but few experiments on this elaſtic fluid; and that excepting the negative facts of extinguiſhing lighted candles, of killing animals, of not being abſorbed either by water, by the acids, or by the alkalis, of not altering, in any manner, certain vegetable colours, facts by which this gaſeous body is diſtinguiſhed from all others, and which characteriſe it, there is no proceſs known to determine the properties of azote in this ſtate, becauſe nothing can deprive it of caloric, and cauſe it to loſe its gaſeous form.

13. Azote gas does not act in any manner on light, neither does light act in any manner on it. It is dilated by caloric, in a relation which is not yet determined, but without changing

ing its nature. It is not united with oxigen in the ſtate of elaſtic fluid: mixed with oxigenous gas, it forms common air in the proportion of 0,73 to 0,27 of the oxigen gas; added to atmoſpheric air, it renders it very dangerous to animals, when its proportion exceeds the third of that which exiſts already in that air; reſpired in a mixture above that laſt proportion, it diminiſhes the vital activity, irritability and heat: phyſicians have begun to mix it thus with air to cauſe it to act as debilitating, cooling, and aſthmic.

14. Though it is certain that oxigen and azote gas, merely mixed, form ſpecies of common air in variable proportions, it is, nevertheleſs, proved, that each of theſe bodies when ſolid or liquid, and particularly azote in the naſcent ſtate, that is to ſay, before it is diſengaged from bodies, and has aſſumed the form of gas, abſorbs oxigen in the gaſeous ſtate. When, under this laſt circumſtance, the quantities of a mixture of theſe two gaſeous bodies are ſo proportioned, that the oxigen gas conſtitutes 0,7, and azote gas 0,3 in weight, and they are expoſed to electric diſcharges, or ſparks; in either caſe, one or both of the gaſes loſe their elaſtic form, become fixed, and unite in ſuch a manner as to form a ſpecies of acid known by the name of nitric, as will be explained more fully in the article of that acid in the third ſection. This reſult alone proves that azote ap-

proximates to combuſtible bodies, and ought to be placed in that claſs.

15. It would be difficult, in this place, to treat of the properties communicated by azote, fixed, liquid or ſolid, to the compounds of which it forms one of the conſtituent principles; beſides which this would not have the advantage which the like information, concerning oxigen, has preſented, becauſe the ſmall number of known combinations of which azote forms a part, do not offer theſe characters of general properties ſimilar to thoſe found in oxigenated bodies, all which reſemble each other in ſuch a manner as to form a ſyſtem of comparative compounds. It is ſufficient therefore to obſerve, that azote exiſts in a ſpecies of alkali; that it is abundantly fixed in animal matters, and in ſome vegetable ſubſtances; and that it gives them certain properties which will be appreciated in another article.

16. We poſſeſs too few facts to enable us to compare the knowledge acquired, concerning azote and azotic gas, with that which has been collected concerning oxigen and oxigen gas. Chemiſtry has ſcarcely commenced the examination of the firſt of theſe bodies, and has, nevertheleſs, made capital diſcoveries on many of its combinations: but much more ſtill remains to be done; and the abundance with which nature has diffuſed azote in the atmoſphere, a truth to which the meditations of philoſophers cannot too ſtrongly be directed, announces that

this principle is one of thoſe which, by the future reſearches of chemiſts, will conduct them fartheſt in the ſtudy of the phenomena of our globe, and to the extenſion of natural philoſophy.

ARTICLE VII.

Concerning Hidrogen, and Hidrogen Gas.

1. ANOTHER ſubſtance preſents itſelf in the ſame ſtate as oxigen and azote; chemiſts have never been able to procure it ſeparate and pure; they have abſolutely no means of procuring it ſo, and they have not yet any proof that it exiſts in that ſtate in nature. They are obliged, in order to diſcover its properties, to examine it in the ſtate of gas, which approaches neareſt to that of its purity, and to examine thoſe properties which it communicates to bodies that contain it, or with which nature preſents it, combined.

2. It is neceſſary, in the firſt place, to know that before the experiments of the French chemiſts, and particularly before the eſtabliſhment of their methodical nomenclature, we poſſeſſed no real knowledge, nor any poſitive idea, about what they denominated hidrogen. Philoſophers who had attended only to ſome of the properties of inflammable air, were not engaged either in diſcovering or in appreciating the

nature and the fixation of its baſe; beſides which they had began to adopt, concerning this ſpecies of gas, notions very different from thoſe which the pneumatic chemiſts have formed of it, and have ſince proved.

3. Hidrogen, according to all the inquiries which have been directed to aſcertain its nature and its properties, is the baſe of pure inflammable gas, which has been named, according to the ſame courſe of the nomenclature, hidrogen gas. It is a body eminently combuſtible, of which the ſpecific character, the ſource of the name which has been given to it, is to form water with oxigen which burns it; it is very ſoluble in caloric, and moſt eaſily aſſumes the gaſeous form the rareſt poſſible; it is found fixed in many combinations; and its properties, exactly and methodically known in the pneumatic experiments and doctrine, have much advanced the general theory of chemiſtry. It is neceſſary to ſtudy hidrogen gas and hidrogen in ſucceſſion.

4. Though we have long poſſeſſed ſome knowledge of the natural inflammable vapours of the mines, and coal pits, as well as of thoſe which are diſengaged in many operations of chemiſtry, ſuch as the metallic ſolutions in the acids, &c.; though their combuſtible and detonating properties have been remarked and deſcribed, as may be ſeen in the works of Boyle, of Hales, of Boerhaave, and of Stahl, it was not till 1766 that M. Cavendiſh well aſcertained the exiſtence

of this elaſtic fluid, and properly diſtinguiſhed it from all others, by collecting ſeparately, and diſtinguiſhing its properties. M. M. Prieſtley, Sennebier, and Volta then ſtudied it with care in moſt of its combinations. It was then called *inflammable air*, or *inflammable gas.* In 1787, by admitting it as formed of a ſimple ſubſtance fuſed in caloric, and by carefully diſtinguiſhing its baſe from the gas itſelf, the pneumatic chemiſts of France have characteriſed it by the words hidrogen gas, and hidrogen.

5. It is not among natural products that hidrogen gas is to be collected. That which is abundantly diſengaged from beds of foſſil coal, moiſtened or expoſed to the air, of putrid vegetables, at the bottom of ſtagnant waters, of ponds, of marſhes, of peat ſoil, contains but a ſmall quantity of pure hidrogen gas. It contains many different ſubſtances in ſolution, and its properties vary ſingularly according to the number and the proportion of theſe ſubſtances. It is the ſame with what exhales from flaming volcanos, red lava flowing into water, and from ſulphureous mineral waters. It will be ſeen hereafter, that theſe gaſes are rather different ſpecies of inflammable gaſes, of which hidrogen gas indeed conſtitutes the baſe, but in which this gas is as the ſolvent of many different matters, and in various proportions.

6. To obtain the pureſt hidrogen gas, or rather the leaſt poſſibly impure, becauſe it is a problem ſtill unreſolved in chemiſtry, to ob-

tain it in a ſtate of perfect purity, the action of water on ignited iron, or a very gentle ſolution of iron or zinc in the diluted ſulphuric or muriatic acid are uſed. During the mutual action of theſe matters, and by the force of elective attractions, which will be explained in the ſixth ſection of this work, the hidrogen gas is diſengaged and collected in a ſuitable apparatus; that is to ſay, in glaſs jars, or flaſks full of water, inverted on the ſhelf of the pneumatic trough, under which are the extremities of the tubes proceeding from the bottles where the ſolutions are inverted. All the other operations in which inflammable gaſes are obtained, ſuch as the diſtillations of organic matters, give but very impure hidrogen gas, from which the different ſubſtances which contaminate it cannot be ſeparated.

7. Hidrogen gas obtained by the two general proceſſes here pointed out, and of which the decompoſition of water is the common ſource, as I have elſewhere proved, and as the word hidrogen and hidrogen gas announce (which words alſo expreſs the fact of its diſengagement from water of which it is one of the principles, or its reſolution into water when it becomes fixed into combinations), has not any viſible difference from common air or any other gas, when it is encloſed in tranſparent veſſels. Nevertheleſs, by the rapidity with which it is diſengaged and elevated in large globes above the water, which it traverſes much more quickly

than any of the other inſoluble gaſes do, and in particular than oxigen gas, common air and azotic gas, we may to a certain point diſtinguiſh and aſcertain them. This quick diſengagement, this accelerated aſcenſion depend on its great levity.

8. When it is as pure as poſſible, hidrogen gas weighs only one-thirteenth part of common air: it is ſeldom that it is obtained ſufficiently pure to poſſeſs this levity. Its uſual weight, according to the experiments of Lavoiſier, is ſuch that a cubic decimetre of this gas amounts to more than 0,94 of a decigram; conſequently a cubic metre weighs 0,94 of a hectogram. (The French cubic inch of hidrogen gas weighs nearly 0,035 of a grain; and the cubic foot 61,15 grains.) It is from this lightneſs, moſt commonly from 9 to 11 exceeding that of air, that the aſcenſion of aeroſtatic machines, or of ſilken bags which contain it, in the air of the atmoſphere, originates, and it is to this magnificent diſcovery of France that philoſophy, which already owes to it the aggrandizement of the power and dominion of man, will hereafter owe to it the knowledge of the phenomena of the atmoſphere, and the creation, as well as the perfecting of meteoric chemiſtry. On account of its lightneſs, it may be contained in open and reverſed veſſels; but if their mouths be turned up, it riſes, and is quickly replaced by the common air.

9. Hidrogen gas is alſo diſtinguiſhed from all the others by its particular odour. Though it

has been diſcovered by experience that its odour is ſingularly augmented by the ſolution of ſome combuſtible bodies which it conceals ſo frequently under its gaſeous form, it is, nevertheleſs, certain, that it is itſelf poſſeſſed of a weak ſmell, conſiderably reſembling that which chemiſts have always diſtinguiſhed by the name of empyreumatic, becauſe, in effect, it is to its ſuperabundance, and to its diſengagement that the oils, deſcribed by that name, owe their odorant character.

10. As ſoon as any inflamed body approaches hidrogen, placed in contact with air, it takes fire, burns more or leſs calmly, without crackling, with a white flame, the colour of which is apt to vary by the leaſt quantity of foreign matter held in ſolution in this gas. Tapers, candles, paper, wood, when lighted, communicate to it, even at the inſtant of contact, their flame, and that at every temperature. The electric ſpark equally inflames it. Charcoal and the metals when ignited, do not inflame it. As it is the lighteſt of all combuſtible bodies, it is alſo the moſt quickly burned. The mere contact of caloric or of light, inſulated from each other, do not cauſe it to take fire. The firſt dilates or rarefies it in a proportion which is not yet known. The ſame is the caſe with the refraction which it cauſes the rays of light to experience: though it is admitted to be ſuperior in proportion to its denſity, and more proportionate to that of its combuſtibility, no

accurate experiment yet permits us to pronounce concerning this important object. No preſſure, however condenſible this gas may be, can ſeparate hidrogen from its ſolvent, and enable us to obtain it ſeparately.

11. The properties already indicated in hidrogen gas (Nos. 7, 8, 9, and 10), prove that it is this which is ſometimes diſengaged in abundance from the ſurface of the earth, elevated in the ſuperior regions of the atmoſphere, and there collected in maſſes more or leſs conſiderable, which, by their ſudden, rapid, or ſucceſſive inflammation, produce the different luminous meteors, ſuch as lightning, thunder, aurora borealis, globes of fire, falling ſtars, ſtreams of light, &c.

12. Hidrogen gas is not of itſelf deſtructive to animal life. Scheele firſt reſpired it ſeveral times ſucceſſively without danger and almoſt without uneaſineſs. Other chemiſts and philoſophers have ſince repeated this experiment with ſucceſs. It therefore depends on the ſenſibility of individuals. When living animals, are kept immerſed in hidrogen gas, they are rendered torpid, and killed, rather from the want of oxigen, than from the injurious impreſſion of this gas. It is more eaſily reſpired, when mixed with oxigen gas or common air. The blood of animals which have periſhed by torpidity in hidrogen gas, is of a deep violet colour almoſt black; their heart and muſcles have loſt all their irritability. The cauſe of theſe phenomena will be explained in one of the laſt ſections of this work.

Hidrogen gas is of no more aſſiſtance to combuſtion than to reſpiration. Lighted or inflamed bodies plunged in it are immediately extinguiſhed.

13. Hidrogen gas experiences no action on the part of oxigen gas; and theſe two fluids mixed in every proportion do not unite at leaſt without remaining very long together: yet this laſt fact is not completely verified. But if, when theſe two gaſes are mixed in the proportion of nearly one part (in volume) of oxigen gas, with two parts of hidrogen gas, or more exactly by weight 0,85 parts of the firſt, and 0,15 parts of the ſecond, an inflamed body be placed in contact with the mixture; or if, in the very centre of this mixture, an electric diſcharge be excited, ſo rapid a combuſtion will take place, that the air will be ſtruck with force, and a violent detonation will be produced. In making this experiment in cloſe veſſels over mercury or water, there is ſcarcely any reſidue, and if the meaſures be exact, abſolutely nothing in the gaſeous form. Both of them are converted by the intimate combination of the two baſes, oxigen and hidrogen, into pure water which correſponds to the whole weight of the two combined fluids. It is from this beautiful experiment, made and many times repeated with all imaginable care, that the French chemiſts have concluded, as will be more completely detailed under the article of water, that this body is a compound of 0,85 of oxigen, and 0,15 of hidrogen.

14. As

14. At it is well proved that common air does not ſupport combuſtion but by means of the oxigen gas which it contains, it is eaſy to comprehend that, in order to burn a given quantity of hidrogen gas, it is neceſſary to mix with it a larger quantity of atmoſpheric air than of oxigen gas; namely, till the proportion of the latter, contained in the common air, be ſuch that it ſhall be nearly ſix times the bulk of the hidrogen gas. Thus, to burn rapidly or to cauſe to detonate two meaſures of hidrogen gas, as in the experiment No. 13, it is neceſſary, inſtead of one meaſure of oxigen gas, to add nearly five parts of common air. The detonation has then nearly the ſame force; all the hidrogen is burned and converted into water, and there is only found, in the aëriform reſidue which remains after the operation, the azotic gas which exiſted in the atmoſpheric air. On this is founded the conſtruction of the eudiometer of Volta, a philoſopher and profeſſor at Pavia. It is a tube in which is inflamed, by the electric ſpark, different mixtures of hidrogen gas, and of the reſpirable airs which are intended to be tried. When the detonation is made, the water is permitted to riſe into the empty ſpace, and the nature of the air which is examined is judged from the diminution of volume. But this proceſs is ſtill more uſeful to explain the diverſity of the compound hidrogenous gaſes, and Citizen Berthollet has employed it with

ſucceſs for that purpoſe, as will be ſhown elſewhere.

15. Since all the preceding facts prove that hidrogen gas is eminently diſtinguiſhed from every other gaſeous body by its inflammability, and from other combuſtible bodies by the water which it forms when combined with oxigen, it follows, that during this laſt combination which takes place, as has been ſeen, by the contact of another inflamed body, or by the electric ſpark, whilſt the two gaſes loſe their elaſtic form, their baſes approximate and condenſe into an aqueous liquid, and that as they combine there muſt be diſengaged a quantity of light and of caloric proportional to the ſtate of denſity which they acquire, and to the capacity for caloric which they aſſume. Lavoiſier and La Place have eſtimated, by their calorimetric experiments, that one part (one pound French) of hidrogen gas, abſorbing in its combuſtion more than five parts and a half (five pounds, ten ounces, five gros, twenty-four grains) of oxigen gas, diſengaged from the latter a quantity of caloric capable of fuſing nearly 300 parts, (295 pounds, 2 ounces, 3½ gros) of ice at 0. Having proved beſides by other experiments, which I ſhall mention under the article of phoſphorus, that this laſt combuſtible body, which diſengages the greateſt portion of caloric from oxigen gas, and abſorbs it as ſolidly as poſſible, may, in effect, diſengage from the ſame quantity of oxigen gas, a proportion of caloric capable of

fuſing more than 377 parts (377 pounds, 12 ounces, 3 gros) of ice, there muſt remain in the water a quantity of caloric, repreſented by more than 82½ parts (82 pounds, 9 ounces, 7½ gros) of ice at 0, that is to ſay, in each part (pound) of water, a portion ſufficient to fuſe 12½ parts (12 pounds, 5 ounces, 2 gros, 48 grains) of ice. Theſe able philoſophers do not, however, reckon the caloric contained in the hidrogen gas, of which a great part is undoubtedly diſengaged, ſince this gas, in liquefying into water, acquires an increaſe of denſity equal to $850 \times 13 = 11050$ more than its baſe poſſeſſed while fuſed in caloric; for the weight of the hidrogenous gas is to that of the air as 13 : 1, and the weight of air to that of the water as 850 : 1. Whence it follows, that the oxigen truly retains in the ſtate of water much more caloric than they have announced, ſince what they have meaſured by the calorimeter was partly derived from the hidrogen gas. But it will be ſeen hereafter that azote, in uniting with oxigen gas, diſengages from it a quantity of caloric much ſmaller, and retains much more of it in its acid combination.

16. Though hidrogen gas unites with oxigen gas only by the effect of combuſtion, excited by the contact of an inflamed body, yet the hidrogen, fixed in a great number of combinations even ſolid, to which it gives, as will be ſeen in the ſections of vegetable and animal compounds, their combuſtibilty, volatility, oily

form, and frequently levity, &c., at the moment when it begins to be diſengaged by the firſt effects of their very eaſy decompoſition, into that ſtate which modern chemiſts have called naſcent hidrogen gas, that is to ſay, at the very inſtant when it tends to aſſume the gaſeous form, it abſorbs very eaſily, and fixes the atmoſpheric oxigen, compoſing water, which is diſſipated in vapour in the atmoſphere, or is collected in little drops on the ſurface of the bodies which preſent this phenomenon. The whole influence of this effect, will be developed under the hiſtory of thoſe ſubſtances in which it takes place.

17. Hidrogen gas can only be mixed without contracting any chemical union with azote gas. But whenever hidrogen gas finds azote in a ſuitable proportion, and when both tend to diſengage themſelves from a ſolid compound uſually complicated, of which they form two conſtituent parts, they unite intimately and form ammonia, a ſpecies of alkali, the properties of which will be examined in the following ſection. Its formation is connected with ſo great a number of chemical facts, that we may reckon the diſcovery, which I here announce, as one of the moſt uſeful truths which the ſcience poſſeſſes. We owe the firſt idea of it to Scheele, and, as will be ſeen below, the exact knowledge or its true acquiſition to Citizen Berthollet.

18. It is almoſt ſuperfluous to remark, that the properties, which I have juſt explained in hidrogen gas, and in hidrogen, though ſtill

only ſuperficial or preliminary, ſuch as the ſtrict order adopted in this work not to treat of the mutual action of bodies but in proportion as they are ſtudied, has permited me to develop them, are among the moſt valuable acquiſitions of the pneumatic doctrine, and that they preſent the moſt numerous, as well as the moſt uſeful applications to every branch of natural philoſophy, which will be proved in the articles which immediately follow.

19. Neither can the uſes, or uſeful properties of hidrogen gas be treated here; becauſe it is impoſſible to employ this body pure, and ſuch as it has been conſidered in this article. Accordingly the inflammable gaſes which are of uſe for affording light, heat, &c. to illuminate bodies, or ſyſtems of bodies, are not really ſuch as they are treated of here, and there will be many other opportunities of ſpeaking of theſe particular gaſes, in different ſections of this work.

ARTICLE VIII.

Concerning Carbon.

1. THE name of carbon has been given, by the French chemiſts, to a ſimple or undecompoſed matter, abundantly contained in the different known ſpecies of coal, but which it is very eſſential ſhould not be confounded with charcoal, properly ſo called. This laſt ſub-

ſtance is moſt frequently a black matter which remains after the partial decompoſitions of vegetable or animal ſubſtances, effected by nature or by art. This matter, beſides the carbon which it conceals in its compoſition, is loaded with many other ſubſtances which are foreign to carbon, which laſt cannot really be ſeparated but by complete combuſtion.

2. It is, therefore, neceſſary, in order to form a proper notion of the nature of carbon, to adopt ideas ſimilar to thoſe which were detailed in the preceding articles concerning oxigen, azote, and hidrogen. Pure carbon does not exiſt in the nature, ſtate, or in the products of the arts, any more than theſe three laſt bodies; or at leaſt, if carbon exiſts pure, or inſulated, in any part of the globe, chemiſts have not yet diſcovered it. But, notwithſtanding this great point of reſemblance, carbon differs, even under this point of view, from oxigen, from azote, and from hidrogen; namely, in this circumſtance, that it is never found united to caloric under the gaſeous form, and alſo that, even in the ſtate of charcoal, it may, at leaſt, in ſome ſpecies of the charcoals, be regarded as nearer to its ſtate of purity, and more proper to exhibit the properties which characteriſe it, than theſe three bodies in any of their combinations.

3. Carbon has alſo another eſſential difference from the three former bodies to which I have compared it; namely, that it is no where ſeen collected in ſuch great maſſes, though it is very

abundant among natural combinations. It is, undoubtedly, one of the principles of which nature diſpoſes with moſt profuſion in the formation of compounds; but it is only diſſeminated in a great number of points, and never combined in a maſs like oxigen and azote gas. It appears, however, that though far from a ſtate of purity, it exiſts, at leaſt, under the foſſil form in depoſitions, or beds, and veins in the interior of the globe.

4. Carbon is procured, not pure and ſeparated from every other body, but more or leſs approaching to purity, by decompoſing moſt vegetable matters, by heat, eſpecially the ligneous bodies which contain a great quantity of it. It is obtained nearly diſengaged, or, at leaſt, in the ſtate of charcoal. The carbon is united with ſome foreign bodies, and a little oxigen, and hidrogen, by volatilizing all the evaporable ſubſtances which are united with it in wood, which proceſs conſtitutes the art of the charcoal burner. The water, in which trees are ſuffered to remain, produces the ſame effect, but more ſlowly upon the ligneous vegetable body. It gradually diſſolves the different ſoluble materials of that body, and leaves its charcoal free.

5. Carbon inſulated by mental abſtraction from the foreign ſubſtances with which it is united in charcoals, appears to exiſt under the form of ſolid particles, of a black ſo determinate, as would lead us to think that it is eſſentially of that colour, and that it communicates it to a

number of other bodies. It is the exceſs of carbon, as will be ſeen hereafter, which produces the greater part of vegetable colours, and which alſo renders them durable and intenſe. It appears alſo, that it gives the ſame ſhade in ſome mineral compounds of which it forms an eſſential part, as will be ſeen in another ſection where I treat of various ferruginous compounds.

But there are, nevertheleſs, reaſons to think that this black colour of charcoals is not a true character of carbon, and that it accompanies its union with a ſmall portion of oxigen and hidrogen from which, in its ſtate of charcoal, it is never exempt.

It will alſo be ſeen, hereafter, that in many compounds, carbon, though very abundant, leaves them frequently a very brilliant white colour, like that of cotton, &c. Laſtly, the diamond which, under certain relations, as will ſoon be ſeen, approaches ſingularly to pure carbon, is ſo much the more white and tranſparent, as it is leſs altered by foreign ſubſtances.

6. Neither taſte nor ſmell are diſtinguiſhable in carbon. Its particles, however denſe their aggregation may be, never poſſeſs an adherence ſufficiently ſtrong to prevent their being very brittle; this brittleneſs is alſo greater in charcoals as the carbon is more contaminated with other bodies. It is probable that the particles of carbon always remain at a very great diſtance from each other. They do not poſſeſs the property of diſpoſing themſelves regularly, and

never permit it to aſſume a cryſtalline form among charcoals. It is probably capable of this arrangement when it is very pure, as I have remarked in the hiſtory of the diamond.

7. Carbon ſtrongly abſorbs light, as the black colour of charcoal proves. It is very fixed in heat, perfectly infuſible and inſoluble by caloric, and it paſſes with juſtice for the moſt refractory body in nature. Thus it is frequently employed as a crucible for containing matters difficult of fuſion, or, as a ſupport, when many bodies are treated by the blow-pipe. As carbon is a bad conductor of heat, it is uſed with ſucceſs to line crucibles, to coat furnaces, and confine the heat; the infuſible property in this body accompanies the property of not conducting caloric. In many of the arts this property becomes of the greateſt utility.

8. Though in the cold and at a low temperature, there does not appear to exiſt any great attraction between oxigen and carbon, and conſequently the charcoal remains unalterable in oxigen gas, which it only abſorbs, and retains ſome time between its particles as it does every gaſeous body; there are, however, a great number of caſes where charcoal, very much divided, has the property of combining with this gas and of becoming gradually diſſolved. This is the ſlow combuſtion of the carbon; this is what takes place without producing light, and without any ſenſible heat, by the contact of organic matters, and of oxigen gas or common air. It is alſo

ſeen among the moſt remarkable phenomena of reſpiration.

9. When the temperature of charcoal is raiſed to ignition, and it is then placed in contact with oxigen gas, the carbon burns with activity, ſparkling, and a ſlightly-brilliant, but very ſenſible flame. It quickly diſappears, becomes fuſed in the oxigen gas, and conſequently aſſumes the fluid elaſtic form. It is found, that twenty-eight parts of carbon may thus diſappear, or be fuſed in ſeventy-two parts of oxigen gas, and that there reſults from this combuſtion and aëriform ſolution of carbon which is its product, a new gas rather leſs voluminous than the oxigen gas which gave its form, of a ſpecific weight almoſt double, and which, as carbonic acid, will be treated of in the third ſection.

10. This combuſtion, one of the moſt beautiful reſults of modern chemiſtry, and of the reſearches of Lavoiſier, diſengages from oxigen gas ſtill much leſs caloric than hidrogen gas does, which is proved not only by the gaſeous form which carbon acquires, and which the oxigen preſerves in that combination, but alſo by the meaſure taken by the calorimeter. Lavoiſier and La Place have found that in the combuſtion of carbon by oxigen gas, a little more than two parts and a half (2 pounds, 9 ounces, 1 gros, 10 grains, French) of the latter, which are neceſſary to burn and diſſolve one part (one pound) of carbon, only loſt a quantity of

caloric repreſented by ninety-ſix parts and a half (96 pounds, 8 ounces) of fuſed ice, whilſt, to become ſolid, the ſame quantity of oxigen gas muſt have loſt a quantity repreſented by more than one hundred and ſeventy-one parts (171 pounds, 6 ounces, 5 gros) of fuſed ice; thus there remained a proportion of caloric repreſented by nearly ſeventy-five parts (74 pounds, 14 ounces, 5 gros) of ice, which proves that one part (one pound) of acid gas which is its product, retains a quantity of caloric which can fuſe nearly twenty-one parts (20 pounds, 15 ounces, 5 gros) of ice. Thus the combuſtion of carbon is one of thoſe which gives leaſt heat and light, becauſe its product retains a portion of thoſe bodies which is neceſſary for it to aſſume the elaſtic form completely.

11. What happens when charcoal is burned in a given quantity of common air, or when that air is not renewed, may be now underſtood. The ignited carbon is combined gradually with the 0,27 of atmoſpheric oxigen gas, and becomes diſſolved in ſuch a manner as to loſe its viſible maſs, and only to leave a few atoms of its aſhes; the air muſt diminiſh but very little of its volume, though the carbon, by diſſolving in oxigenous gas, approximates and condenſes its particles; inſtead of this gas, the air is found to be ſpeedily charged with a gaſeous acid mixed with azotic gas, which amounts to 0, 73. Thus the air, vitiated and really deſtroyed, as to its vital and reſpirable parts, by this combuſtion,

produces very fatal accidents. It will be alſo ſeen that other circumſtances, relative to charcoal, alſo augment its danger.

12. There is no known action between carbon and azotic gas. This laſt does not appear to have any ſenſible attraction for charcoal. It will be ſeen that it combines with it eaſily and abundantly, when a third principle, hidrogen, adds its attraction to that of the other. The compounds of azote, of hidrogen and carbon, which often contain more or leſs of oxigen, are very frequent among vegetable and animal matters; the pruſſic acid, an important product which will be examined elſewhere, is one of its compounds.

13. There exiſts ſo marked an attraction between carbon and hidrogen, that this compound named carbonated hidrogen, or hidrogenated carbon, accordingly as the proportion is greater in either, is frequently met with among vegetable compounds. But, beſides this attraction of the radicals, hidrogen gas may eaſily hold in ſolution a greater or leſs quantity of carbon, which happens whenever it is diſengaged from a ſubſtance which itſelf contains carbon more or leſs abundant and divided. This ſolution, which is obtained very varied, and in a number of chemical operations, from the ſimple expoſure of charcoal, in a bell full of hidrogenous gas to the rays of the ſun, (in which expoſure the charcoal is ſeen to diſſipate, and the hidrogenous gas to diminiſh in volume, in proportion as

it is diſſolved,) to the rapid decompoſitions by heat, or the ſlow and ſpontaneous change which vegetable and animal ſubſtances undergo at the bottom of waters. In all theſe circumſtances, carbonated hidrogen gas is obtained. Charcoal itſelf, when humid, or when it has been for ſome time immerſed in hidrogen gas, begins, when lighted, to exhale through the atmoſphere this deleterious gas, which alſo augments the danger of its combuſtion in cloſe places.

14. Carbonated hidrogen gas, formed ſo eaſily in all the conditions here explained, varies, as has already been ſaid, according to the proportions of carbon which it contains, and aſſumes properties varied, alſo according to theſe proportions, in ſuch a manner that it has been regarded and deſcribed as if it formed ſo many different inflammable gaſes. That which is diſengaged from ſtagnant waters and the bogs, from peat, from peat-grounds, privies, and ſinks; that which is obtained from the ſolution of ſome carbonated metals during their oxidation in the weak acids; that which frequently exhales from coal pits, from the mouths of volcanos; thoſe gaſes which are derived from vegetable and animal matters diſtilled at different temperatures, from alcohol, from ether, from oils, treated by different re-agents, particularly by the concentrated acids;—all theſe different inflammable gaſes, which will be treated of in many of the other articles of this work, are carbonated

hidrogenous gas, forming as many varieties as there are different proportions of their principles; and ſometimes alſo other combuſtible matters are added to the carbon, diſſolved in hidrogen gas, which always forms its baſe or radical.

15. However numerous the varieties of carbonated hidrogen gas may then appear, as well as the properties which it preſents, there may however, be diſcovered in the whole of theſe varieties, a ſeries of characters which connect them, and which conſtitute them a diſtinct genus of compounds. It is very evident, that we muſt here attend only to the generic characters. Carbonated hidrogen gas is heavier than pure hidrogen gas; and can but ſeldom be uſed for inflating aeroſtatic machines; it has a fetid odour which is ſo much the ſtronger, as it holds more of carbon in ſolution; it extinguiſhes inflamed combuſtible bodies, and more completely ſtupifies animals than pure hidrogen gas; it, in general, burns with leſs rapidity than this laſt: its flame is often blue and pale; ſometimes it is red or white, very brilliant, and, as it were, oily. It frequently depoſits carbon, diſtinguiſhable by its black colour, when treated by different proceſſes; it is, in general, more eaſily and more abundantly condenſed, or abſorbed, by charcoal. In ſome circumſtances, it forms oil, and it has then been particularly named olefiant gas. It will be again ſpoken of in the ſections concerning vegetable and animal matters, which in their decompoſition, afford the moſt numerous

and moſt remarkable varieties. An accurate analyſis has been made of it by combuſtion in the eudiometric apparatus of Volta: it always affords, by burning, more or leſs of the acid formed by carbon and oxigen.

16. I have now deſcribed the general properties of carbonated hidrogen gas. Hidrogenated carbon exiſts ſolid in almoſt all the charcoals which retain more or leſs of hidrogen, frequently united with a little oxigen. It is, for this reaſon, that all the charcoals, burned in the pneumatico-chemical apparatus, give out carbonated hidrogen gas and carbonic acid. It is alſo, for this reaſon, that, when burned in determinate quantities of oxigen gas, the charcoals afford water at the ſame time with carbonic acid. The preſence of hidrogen in charcoals explains alſo the infectious odour, and the pernicious gas which ariſe from them in their firſt moments of combuſtion, and when they begin to take fire. Thus, at preſent, the vegetable and animal charcoals are conſidered as *oxides of hidrogenated carbon.* This conſideration, which will be repreſented hereafter, leads us, as I ſhall ſhow elſewhere, to reſults of the greateſt importance for the explanation of a very great number of the phenomena of nature and the arts.

17. The uſes of carbon are very numerous in chemiſtry; its powerful attraction for oxigen is employed with great ſucceſs. After hidrogen, this ſubſtance attracts it moſt ſtrongly; and, at high temperatures, it is the moſt

ſtrongly attracted by oxigen: it is, for this reaſon, that I have placed it immediately after hidrogen, in the arrangement of all the combuſtible bodies according to their elective attraction for that principle. It will be ſeen in the following articles, that carbon is particularly uſed, to diſoxigenate many burned bodies, to reduce them to their ſimple ſtate of combuſtibility, and to develop many of theſe laſt. It is no longer doubtful, even according to the few facts which I have been urged to repeat in this article, by the order generally adopted in the preſent work, that carbon is a principle uſed by Nature, forming the greateſt number of her compounds: it will be proved hereafter that it conſtitutes the baſe of all vegetable ſubſtances, and that it performs a very important part in the great work of animalization.

ARTICLE IX.

Concerning Phoſphorus.

1. Phoſphorus is the fourth ſimple or undecompoſed combuſtible ſubſtance, placed in this ſection; becauſe azote muſt be arranged among theſe bodies on account of its attraction and combination with oxigen. Phoſphorus holds the third place among theſe matters (azote having been placed in the firſt place only, on account of its great abundance in nature, and its

exiſtence in the air), becauſe it occupies, in effect, this rank in the order of its attraction for oxigen.

2. The word phoſphorus, which implies *the bearer of light*, has been given to this combuſtible body, becauſe it is conſtantly luminous in the air, and becauſe it is, of all the ſpontaneouſly-luminous bodies, that which emits the greateſt ſplendor for the longeſt term; properties which depend on its peculiar and combuſtible nature; whereas moſt other luminous ſubſtances only poſſeſs phoſphoreſcence as if by accident, and the greater part of them exhale as it were, the light with which they have been penetrated. The word phoſphoreſcence, expreſſing a general property, ought then to be carefully diſtinguiſhed from that of phoſphorus which deſignates and repreſents a particular ſubſtance.

3. Phoſphorus is yet a new acquiſition among men; it has for a long time been unknown to them, and, as it were, concealed from their eyes by Nature; or if the ancients poſſeſſed it, and knew how to extract it from its natural combinations, neither hiſtory, nor tradition, have preſerved any trace of that diſcovery. It was towards the end of the ſeventeenth century only that this body was diſcovered; and more than ſixty years of labour have ſcarcely afforded chemiſts the knowledge of conſtantly obtaining it in ſufficient quantity to make their experiments. And ſtill, notwithſtanding all the im-

provements which the art of extracting phoſphorus has acquired during the fifty laſt years of the eighteeth century, we are far from poſſeſſing this combuſtible body in a quantity as conſiderable as all the others, and of being able conſequently to employ it like them in the reſearches of chemiſtry.

4. An alchemiſt of Hamburgh, named Brandt, who, in ſearching for the philoſopher's ſtone which he did not find, was the firſt who, by chance, in 1677, diſcovered this phoſphorus for which he did not ſeek. The ſingularity of this new product induced Kunckel to aſſociate with one of his friends, named Kraft, to purchaſe the ſecret of its preparation: but this laſt having deceived his friend by procuring the ſecret for himſelf, of which Kunckel knew nothing more than that the phoſphorus was prepared from urine, this philoſopher had the courage to undertake the work of diſcovery. He, at laſt, ſucceeded in obtaining phoſphorus, which was long called the phoſphorus of Kunckel, on account of the ſucceſs of his enlightened reſearches. Boyle paſſes alſo for having diſcovered phoſphorus, and having depoſited the proceſs with the ſecretaty of the Royal Society of London in 1680. In 1679, Kraft brought a ſmall piece of it to London to ſhow it the king and queen of England. Boyle gave his proceſs to Godfried Hankwitz, a practical chemiſt of London, who, for many years, ſold the product to all the philoſophers of Europe. This laſt

operator, and Kunckel, were, for ſome time, the only chemiſts who knew how to prepare it. Boyle, however, deſcribed his proceſs in the philoſophical tranſactions for 1680; and Kraft inſerted his own, after having ſeveral times ſold it, in a Treatiſe on Phoſphorus, by the Abbé de Commines, publiſhed in the Mercury of June 1683. That of Brandt was communicated in Hooke's Philoſophical Collections, publiſhed in Engliſh in 1726 by Derham. Homberg publiſhed a proceſs, which he ſaid he had ſeen practiſed by Kunckel, in the Memoirs of the Academy of Sciences for 1692. Techmeyer, Hoffman, Niewentyt, and ſeveral other chemiſts, ſucceſſively deſcribed proceſſes for obtaining phoſphorus; notwithſtanding which, this operation was not practiſed in the laboratories of chemiſts, till a foreigner having ſold to the French government, in 1737, a proceſs for obtaining it, and the Academy of Sciences of Paris having cauſed it to be repeated by Dufay, Geoffroy, Duhamel, and Hellot, this laſt philoſopher deſcribed the ſucceſsful experiment with much care and perſpicuity of expreſſion. Rouelle, the elder, made phoſphorus in the courſe of chemiſtry, which he delivered at Paris for ſeveral years after this period of 1737. Margraf, in 1743, made a remarkable improvement in the proceſs, by preſcribing the addition of muriate of lead to the extract of urine and charcoal. Thirty ſucceeding years paſſed before any remarkable advancement was made in the extraction of phoſphorus. It was made but ſeldom, with difficulty and in ſmall quantities in the laboratories, and it was ſtill them ere object of curioſity and the ſubject of a few philoſophical experiments. A ſmall ſtick or two of phoſphorus uſually compoſed the whole portion in cabinets, when in 1774, Gahn and Scheele in Sweden made a capital diſcovery, which greatly augmented the quantity of phoſphorus produced in the laboratories, by ſhowing that the acid from which it was extracted is abundantly contained in the bones of animals, and by giving eaſy proceſſes for the ſeparation of theſe ſolid animal parts. The proceſs of Scheele has been very much improved in France by Nicolas and by Pelletier: but, notwithſtanding all theſe reſearches, it is ſtill the ſcarceſt, the moſt expenſive, and conſequently the leaſt employed of ſimple combuſtible bodies.

5. Phoſphorus undoubtedly exiſts in much greater abundance in nature than has been hitherto thought; in proportion as mineral chemiſtry has advanced, it has been found in many more compounds than has been imagined. It exiſts in combination with different matters, but never pure and inſulated. Though it has hitherto been found moſt frequently burned in the compounds of which it forms one of the principles, it is very probable that it is alſo combined, in the combuſtible ſtate, in many foſſils, and eſpecially in the ores. It is alſo extracted, but in very ſmall quantity, from a great

number of vegetable ſubſtances; and it is ſo abundantly contained in many animal matters, that it was long thought to be peculiar to this genus of bodies. It is always from one or the other of theſe natural compounds, where it exiſts in the burned ſtate that it is ſeparated by diſoxigenation, by ignited charcoal, as will be more fully deſcribed hereafter. It is particularly from urine, and from the bones of animals that it is commonly extracted. It may, as will be explained in another ſection of this work, be obtained much more eaſily, and with leſs expence, from ſome ores of lead.

6. Phoſphorus, which from what has been ſaid, may be always conſidered as a product of art, or rather as extracted by art, ſince nature no where preſents it pure and inſulated, is uſually a ſolid body, ſemi-tranſparent, ſlightly brilliant, of a conſiſtence reſembling wax, ſoftening at a temperature of a few degrees above 0, ductile at 25 degrees of the thermometer, brittle if ſtruck, or attempted to be bent, particularly if colder than 0; eaſily cut, or ſcraped, preſenting a vitreous, brilliant, and ſometimes ſlightly-lamellated fracture.

7. I have found the ſpecific gravity of phoſphorus equal to 2,0332, water being 1,0000. Its taſte is ſlightly acrid and diſagreeable; it emits a very ſenſible and diſtinguiſhable ſmell of garlic; and cryſtallizes either in needles, or in micaceous plates, or in oblong octahedra which preſent a great number of varieties.

8. Phoſphorus undergoes a ſlight alteration from light; by refracting it in a ratio greater than according to its denſity, and which appears to follow its combuſtibility, it becomes red-coloured, and ductile if it was brittle before. It is much diſpoſed to change its ſtate by caloric. At 25 degrees of temperature, it is very ſoft and ductile; at 32 of the thermometer of Reaumur, it melts, and flows like a tranſparent colourleſs oil: the ſame effect almoſt takes place when it is expoſed during ſome time to the contact of the human ſkin, becauſe at leſs than 32 degrees of heat, it becomes nearly liquid. If it be left to cool ſlowly after having been fuſed, it aſſumes a cryſtalline form. When its ſurface, has become ſolid, if it be broken while ſtill fluid, and the portion within be ſuffered to flow out, the interior ſurface is found lined with priſmatic needles, or oblong octahedral cryſtals. At 76 degrees, it is converted into vapour; at 86, it begins to collect in drops in the neck of the retort in which it is heated with water. When it it is heated without water in a retort, by plunging a thermometer graduated to the ebullition of mercury, according to the diviſions of Reaumur, into it, it is ſeen to boil at 232 degrees of that graduation, at which time the drops ſucceed without interruption by the beak of the retort. It was by diſtillation that it was formerly rectified in ſmall retorts of glaſs, to which a receiver was adapted half filled with water: at preſent, we are content to purify it

by fuſion in tubes plunged in warm water; its ſaline, or impure parts are collected at the ſurface. It is alſo paſſed through a ſkin of new chamois leather, plunged beneath warm water: its impurities are detained by the ſkin, and the phoſphorus which paſſes is very clean, and almoſt tranſparent.

9. Phoſphorus immerſed in oxigen gas does not undergo any alteration, nor emit any ſmoke viſible in the day, nor light in the night, if that gas be very pure: conſequently it is not burned in the cold in this oxigen gas. But if, when it is fuſed, it is placed in contact with this gas, it inflames at the inſtant of contact, and expands a light ſo vivid and ſo ſtrong, that the eye cannot endure its ſplendor: at the ſame time that much caloric is diſengaged. The oxigen gas loſes its aërial form; if it be very pure, and without mixture of any other gas, it diſappears entirely, and becomes ſolid in the phoſphorus. This combuſtion of fuſed phoſphorus in oxigen gas is the moſt beautiful ſpectacle of light which chemical experiments preſent; the flame is almoſt as brilliant as the diſk of the ſun, and the eye is much hurt by it.

10. Phoſphorus is alſo a body which diſengages moſt caloric from oxigen gas at the moment of inflammation. Lavoiſier and La Place have proved by their calorimetric experiments, that, from half a kilogramme (1 pound) of oxigen gas employed to burn phoſphorus, there was diſengaged a quantity of caloric capable of

fuſing more than thirty-three kilogrammes (66 pounds, 10 ounces, 5 gros, 24 grains) of ice at 0; that it was of all combuſtible bodies that which diſengaged moſt of this principle; that oxigen united to phoſphorus after that combuſtion might be regarded as the moſt ſolid poſſible, and at the *maximum* of its concreſcibility; that phoſphorus abſorbs once and a half its weight of oxigen, and converts it into white, cryſtalline, niviform flakes of an acid, which will be examined in the next ſection under the name of phoſphoric acid. Phoſphorus thus fuſed may be burned at the bottom of water, by bringing oxigen gas in contact with it, and in this caſe the acid is diſſolved.

11. Atmoſpheric air acts very differently from oxigen gas on phoſphorus. When this combuſtible body, at the loweſt temperature, even at ſome degrees beneath the 0, is plunged into common air, if it be during the day, the phoſphorus is ſeen to be involved in a white vapour, or ſmoke; if in the night, this vapour appears in the form of a greeniſh-white light, undulating, and preſenting in the moſt perfect obſcurity, very expanſible luminous rays, rapidly ſpreading in ſpace, and which do not diſappear but at ſome diſtance from the phoſphorus whence they proceeded. This luminous vapour, which is not accompanied with any ſenſible diſengagement of caloric, and does not give heat to other combuſtible bodies, is the moſt anciently known phenomenon of phoſphorus. It is

this which has given it the name which it bears; it is this alſo which has formed, for a long time, the ſole object of the experiments on the phyſical properties of this body, and which alone has concentred, in ſome meaſure, during more than ſixty years the whole attention of philoſophers. When phoſphorus is thus expoſed in the midſt of the atmoſphere, it continues to burn and emit light while the ſmalleſt particle remains; becauſe it gradually diſappears in the air, or evaporates, and is carried away by the atmoſpheric humidity. If this experiment, which is termed the ſlow combuſtion of phoſphorus, be made in a cloſe apparatus under a bell-glaſs where the air is ſlowly renewed by lateral openings, or by placing phoſphorus on a funnel ſupported by a bottle, the acid which is formed, and which gradually diſſolves in the atmoſpheric water which it attracts, is collected in the bottle. This is the phoſphoreous acid, different from that which is obtained by the rapid combuſtion of phoſphorus fuſed in oxigenous gas. It will be examined in the following ſection.

12. Since, in the preceding experiment, phoſphorus burns by means of the oxigen gas contained in the common air, and as it entirely abſorbs the oxigen, it is evident, that it may be advantageouſly uſed in this ſpecies of combuſtion to analyſe the air, and to conſtitute an eudiometric proceſs. For this purpoſe it is introduced into a tube, corked at one of its extremities, and ſupported by the other, which is open on the board

of an hidro-pneumatic veſſel, an accurate and well-known meaſure of the air intended to be analyſed; a ſtick of phoſphorus, ſupported on a glaſs rod is then introduced and is left there till no more of the white vapour is ſeen about it during the day, or of light during the night. The phoſphorus is then removed or drawn down, and the quantity of oxigen gas which has diſappeared, is meaſured by the diminution thus obtained. The reſidue is, in fact, merely azote gas. M. Humboldt, however, aſſerts, that there remains 0,02 to 0,03 of oxigen gas united with phoſphorated azotic gas, and that this means of indicating the proportion of atmoſpheric oxigen is not ſufficiently exact for eudiometry.

13. Since phoſphorus burns ſlowly, though conſtantly, expanding its light in the atmoſpheric air at every temperature which exiſts in our climate, it follows, that it is impoſſible to preſerve this combuſtible body in ordinary veſſels partly filled with air, as is done with all other bodies. It is carefully kept under water that has been boiled, notwithſtanding which it is always altered at its ſurface by the little air which that water abſorbs when the veſſel is uncorked. In the courſe of time, it loſes its ſemitranſparence, becoming at firſt white, opaque, and, as it were, farinaceous, and the water aſſumes the character of phoſphoreous acid. The ſurface of phoſphorus thus altered, forms what is called oxide of phoſphorus: it is the commencement of a combination with oxigen,

which is not ſufficiently abundant to bring it to the ſtate of acid.

14. If the temperature of phoſphorus expoſed to the atmoſphere, or in a quantity of common air, be elevated to below forty degrees (centigrade), or even a little lower, the ſlow combuſtion quickly gives place to a rapid combuſtion, or deflagration accompanied by ſcintillation, complete fuſion and boiling of the phoſphorus, by a vivid light, and an ardent heat; and, inſtead of phoſphoreous acid, phoſphoric acid is obtained as in oxigen gas. This rapid combuſtion in the air differs from that which takes place in oxigen only, by the leſs quantity of light and energy, and in its always leaving a gaſeous reſidue, after the complete abſorption of the oxigen of atmoſpheric azotic gas holding phoſphorus in ſolution, Citizen Seguin has, therefore, propoſed it as an eudiometric proceſs. A tube of glaſs dilated toward the bottom is uſed for this purpoſe; it is filled with mercury, and laid on the ſhelf of the hidrargyro-pneumatic apparatus; a very dry particle of phoſphorus is introduced into it, which riſes to the top. Care is taken that it ſhall be more than is neceſſary for the volume of air which is intended to be examined. The phoſphorus is fuſed by moving a piece of ignited charcoal above the tube, and then the air is introduced in a well-known quantity, the combuſtion of phoſphorus quickly takes place; a calculation is formed, from the aëriform reſidue

when cold, of the reſpective proportion of the oxigen gas and azote contained in the air thus eſſayed. If, as M. Humboldt aſſerts, there conſtantly remains two or three hundredths of oxigen gas mixed with the reſidue of the phoſphorated azotic gas, this eudiometric method is not entitled to all the confidence which has been placed in it.

15. Phoſphorus, whenever it acquires in the air a temperature of a few degrees ſuperior to that of the human body, takes fire and heats all the bodies near it; as it acquires, in this rapid combuſtion, a very ſtrong heat, and powerfully burns the moſt ſolid organs, and a briſk rubbing, or even very gentle friction, if continued for ſome time, may bring it to this temperature, it is highly neceſſary to take the greateſt precaution in experiments with this body, of which many chemiſts have already been the victims. It is a ſubſtance which ought carefully to be removed from all economical uſes, and ought to be truſted only to prudent and attentive men. It always endangers thoſe who frequently uſe it, with the probability of ſetting fire to apartments, or ſevere perſonal burning.

16. It appears ſtrange, at firſt ſight, that a body ſo combuſtible and ſo inflammable as phoſphorus ſhould not burn in oxigen gas except when conſiderably heated; that it ſhould not enter into the moſt rapid combuſtion, nor even preſent the ſlow combuſtion, while it undergoes this laſt even in temperatures approaching that

of ice in common air. The cauſe of this phenomenon ſo ſingular in appearance, may be ſhewn by examining the effects of azotic gas on phoſphorus. It is diſſolved with facility, in the azotic gas in vapours, and ſaturates it without burning or affording light; and when this phoſphorated azotic gas is mixed with oxigen gas, even at a low temperature, light appears, and a ſlow combuſtion takes place. This is the reaſon, why, upon adding oxigen gas to the atmoſpheric gas of the analyſis left from the air by phoſphorus, however that analyſis may have been made, the mixture of theſe two gaſes burns with a very ſenſible light. Phoſphorus cannot burn ſlowly, and paſs to the ſtate of phoſphoreous acid in oxigen gas, until after having been diſſolved in another gas, or unleſs the oxigen gas is mixed with ſome other elaſtic fluid which can firſt diſſolve the phoſphorus. Thus in the air of the atmoſphere, in which this combuſtible body is plunged, it is firſt diſſolved in the azote gas, and it only burns by abſorbing oxigen in proportion as its ſolution is effected by the former gas.

17. Hidrogen and phoſphorus attract each other. When phoſphorus remains in hidrogenous gas, a ſmall portion is diſſolved which communicates a peculiar odour, and the property of emitting light when it is afterwards mixed with oxigen gas. This is not, however, the ſtrongeſt action which theſe two bodies can exert on each other, nor the moſt intimate com-

bination which can be formed between them. A much greater proportion of phoſphorus may be diſſolved in hidrogen gas by a more complicated method, which will be deſcribed in one of the following ſections, than can be done by the ſimple contact here mentioned. Phoſphorated hidrogenous gas is then obtained, which was diſcovered twelve years ago by Citizen Gengembre, and which has a fetid ſmell of garlic, and a ſpecific gravity much more conſiderable than that of hidrogen gas. It poſſeſſes the remarkable and characteriſtic property of taking fire by the mere contact of oxigen gas, or of common air, and of burning with a very brilliant white flame. It will be treated more fully in the fourth ſection.

18. No direct combination is yet known between carbon and phoſphorus, though it is probable that it exiſts. It is only known that theſe two combuſtible bodies are frequently united together, and with hidrogen and azote in vegetable and animal ſubſtances.

19. Phoſphorus is ſtill confined to a very few uſes. It is ſeldom uſed in medicine, and the accurate experiments yet made to explain its properties are but few; it even appears, according to ſome late experiments, that it is a poiſon to animals. It ſhould not, therefore, be tried on man but with much care and caution. In the arts, it is uſeful only in a few proceſſes, and for the common purpoſes of life it is dangerous.

In natural philoſophy it is little more than an object of curioſity.

20. It is to chemiſtry that it has already rendered, and ſtill may render the greateſt ſervices. Its elective attractions for oxigen, and for ſeveral other bodies, render it highly valuable. It is certain, that its properties and combinations have ſcarcely yet begun to be examined. Every thing announces, that when we ſhall be able to prepare it more eaſily than has hitherto been done, when it ſhall be extracted in greater quantity, and with leſs loſs from its compounds than we have yet been able to do; when, in a word, it ſhall be obtained in more conſiderable maſſes, it will become one of the moſt valuable inſtruments of analyſis and ſyntheſis. The accounts to be given in many of the following ſections of its action on various bodies, will ſimply prove and illuſtrate this important truth.

ARTICLE X.

Concerning Sulphur.

1. SULPHUR, a combuſtible body, ſimple and undecompoſed like the preceding, and the fourth in the order of elective attraction for oxigen, is the moſt eaſily procured in a ſtate of purity, becauſe nature preſents it frequently and very abundantly in that ſtate. The moſt

ancient, and, perhaps, the firſt known of all combuſtibles, it has long been conſidered as the general cauſe, or indication of combuſtibility; which has been attributed principally to the preſence of ſulphur. This name has even been given to very different inflammable ſubſtances: the powder of Lycopodium has thus been named the *vegetable ſulphur*.

2. Though very anciently known, ſulphur has alſo been long a ſource of errors and of hypotheſes in chemiſtry. It has been thought to be a compound, decompoſable and recompoſable of many parts. It was on this ſubſtance, that the ingenious Stahl moſt particularly eſtabliſhed the theory of phlogiſton, which has governed the ſchools during a century. Since the eſtabliſhment of the pneumatic doctrine, the facts have been accurately obſerved and much better examined, and the phenomena preſented by ſulphur have proved, that it has not been decompoſed; that it only obeys the laws of compoſition, and is acted upon in this reſpect, like phoſphorus, carbon, the metals, &c. In general, ſulphur, even conſidered as a principal ſubject in chemiſtry, has been at all times one of thoſe which have participated the moſt in the different changes which the ſcience has experienced, and concerning which philoſophers have been more particularly employed. Sulphur is conſequently a body whoſe combinations are the moſt numerous, and, at preſent, the beſt underſtood.

3. Sulphur is found very abundantly in nature, it is one of the primitive materials employed in moſt of her combinations. Though it is no where found in large maſſes, in beds, or in veins really continued within the globe, yet, on the other hand, it is diſſeminated every where. In ſome places it forms depoſitions, incruſtations, ſtalactites; in others, it is diſſolved in waters by means of a particular combination, and is collected at their ſurface, or precipitated among the bodies which occupy their beds; it is ſublimed, or flows in fuſion from burning volcanos, or from ſeveral ſoils formerly volcanized; it is concealed in the earth, combined with a great number of metals; is met with in many vegetables, particularly in the cruciferæ; and it is alſo extracted from animal matters.

4. In theſe places where nature preſents ſulphur, ſo abundantly, that the ſoil is ſometimes ſo impregnated with it as to be every where apparent, it is eaſily collected whenever a cold ſpace is preſented to the vapours which exhale from the hot ſoil that contains it. In this manner it is obtained in the ſulphureous grounds, named *ſolfaterra* in Italy. It is alſo ſeparated from the metallic combinations by heat: and by this method, it is extracted for the arts and chemiſtry. In order to purify it, it is fuſed; then left to repoſe; and afterwards caſt in cylindrical moulds of wood, in the form called roll-brimſtone.

5. Very pure ſulphur is a ſolid body, of a peculiar yellow, of a very beautiful ſemi-tranſparence when it has ſlowly acquired its aggregation: in which circumſtances it conſtantly aſſumes the octahedral form. The modern cryſtalogiſts have acknowledged four varieties of this form.

a. The octahedron with ſaline triangular faces; this is the primitive form of its integrant particles, as is proved by the diſſection of the cryſtals combined with the computation of the laws of diminutions, by which their arrangement is capable of producing the other forms; *b.* the primitive octahedron, of which the two pyramids are uſually ſeparated by a very ſhort priſm; *c.* the primitive octahedron, of which the ſummit is replaced by a face perpendicular to the axis: this is improperly named the truncated octahedron; *d.* the preceding variety, the terminal faces of which have their four ſides replaced by as many facets.

6. Sulphur, extracted from minerals, and purified by art, is never tranſparent, nor regularly cryſtallized. It is always found opaque, granulated, and, as it were, laminated in its fracture, and becomes electric by friction. Native ſulphur has the ſpecific gravity of 2,0332; that which has been fuſed does not exceed 1,9907, according to Briſſon. It is very brittle, and eaſily reducible to powder; has no very determinate taſte, though when left ſome time in the mouth, it is not perfectly inſipid. When it is

rubbed for a time, it appears to be volatilized in the ſurrounding air, ſo as to form an atmoſphere, perceptible to the ſenſe, by a peculiar odour, ſlightly fetid, and well adapted to characteriſe, or diſtinguiſh it. If a roll of ſulphur be preſſed for ſome time, or even if it be held in the hand, without preſſure, it crackles, and breaks into many ſmall pieces; it leaves on the ſkin a very ſtrong ſmell, which remains for ſeveral hours. It partly loſes its colour by levigation, and more eſpecially by chemical diviſion, ſuch as takes place in precipitation: it then ſometimes becomes grey or white.

7. No ſenſible effect of light on ſulphur has been obſerved; that which nature preſents tranſparent, produces a ſtronger refraction of it than it could produce according to the ratio of its denſity: it appears that it follows its alterability by caloric. Light alſo ſenſibly colours the powder of ſulphur when it is white; it tends to reſtore the yellow ſhade.

8. Caloric dilates ſulphur; at a temperature ſuperior to that of boiling water, it melts, and flows ſlightly viſcid. It becomes tranſparent by fuſion, and aſſumes a browniſh-red colour, but reſumes its yellow colour by cooling, if it has not been long kept in fuſion. If it be ſlowly cooled, it aſſumes an irregular, needled, or priſmatic form, on account of the ſtate of viſcous fluidity which it had acquired. By continuing the heat, it becomes thick, as it were ſyrupy, and if then poured into cold water, it retains a de-

gree of ſoftneſs, which renders it very valuable for impreſſions of ſeals, &c. When fuſed in a well-cloſed apparatus, it is ſublimed, and fixed in very fine needles, forming a powder which is known under the improper name of flowers of ſulphur. As it ſeldom happens, that there is not a ſmall quantity burned in this proceſs, the ſublimed ſulphur, or the flowers of ſulphur, are uſually, in a ſlight degree, acid: ſometimes they are ſufficiently ſo to moiſten in the air. Hence, for medical uſes, it is neceſſary to waſh out this acid portion.

9. Sulphur does not combine in the cold with oxigen gas; when plunged in fuſion, and well heated in this gas, it burns with a flame of a brilliant, and almoſt white-blue colour; it diſengages much heat, though leſs than phoſphorus, and is converted, by the abſorption of oxigen, into a very ſtrong acid, named ſulphuric acid, which will be amply treated in the following ſection. It is not exactly known how much ſulphur abſorbs of oxigen in this combuſtion, nor how much caloric it ſeparates from the gas. It appears that it abſorbs nearly half its weight, and diſengages between a third and a half leſs of caloric than phoſphorus does, from the portion of oxigen gas, of which it ſolidifies the baſe in burning. In the courſe of this phenomenon it is ſeen, that a rapid combuſtion of ſulphur takes place; it is effected almoſt without ſmell.

10. This body undergoes merely a ſlow combuſtion when it is heated in contact with the atmoſpheric air; in the cold, it undergoes no alteration. If it be kept ſimply fuſed, without being heated above fuſion, in common air, it abſorbs only a very ſmall quantity of oxigen, and forms a reddiſh-brown maſs, of a ſlightly-ſour taſte, which not yet being acid, bears the name of oxide of ſulphur. If it be heated ſufficiently to take fire, or its powder be ſet on fire by the contact of an inflammable body, it burns with a flame of a pale blue, and emits a ſtrong, irritating, and ſuffocating ſmell. The acid which it forms in this ſlow combuſtion is volatile, odorant, and very weak, in compariſon with that which is the product of its rapid combuſtion. It is called ſulphureous acid; and differs from the former, by a ſmaller proportion of oxigen, as will be ſeen in the third ſection of this work. It is eaſily collected by burning ſulphur in an earthen veſſel, placed in another veſſel filled with water, which is covered with a glaſs bell. The vapour, which exhales in this proceſs, is diſſolved in the water, which riſes in the bell to fill the void formed by the abſorption of the oxigen. It was thus that formerly the *ſpirit of ſulphur by the bell* was prepared.

11. The phenomena of the two preceding combuſtions of ſulphur prove, that this body is much leſs combuſtible than the preceding, ſince it neither produces the ſame heat, nor the ſame light, nor abſorbs the ſame quantity of oxigen,

and becauſe it requires a much longer time to effect this proceſs. It is alſo found, by accurate experiments, that ſulphur, lighted in the air, is far from abſorbing the 0,27 of oxigen which it contains, and that when its combuſtion has ceaſed, phoſphorus and pyrophorus can ſtill burn in that air. So that ſulphur has leſs tendency to become oxigenated than hidrogen, carbon, and phoſphorus, which, in effect, deprive it of oxigen, as will be ſhown below. Hence, it is evident, that the ſimple combuſtion of pure ſulphur cannot be of uſe in eudiometric proceſſes.

12. But, when ſulphur is very much divided, as it is in a great many of its combinations, particularly when diſſolved in liquids, it burns without flame, and without heat in the air, completely abſorbing its oxigen, and becomes converted into ſulphuric acid. In the other articles, the circumſtances will be deſcribed, wherein this inſenſible, but nevertheleſs complete, combuſtion of ſulphur takes place, as well as the application which has been made of many of theſe circumſtances to eudiometry. They are only indicated here for the purpoſe of combining or approximating all the phenomena relative to the combuſtion of ſulphur, and to its combination with oxigen.

13. There is no known union between azote and ſulphur, though theſe two bodies are frequently found combined, but together with many others, in vegetable and animal ſub-

ſtances. Azotic gas diſſolves a little ſulphur when it is heated in a veſſel of that elaſtic fluid. The ſulphurated azotic gas is fetid; it depoſits a part of the ſulphur when the temperature is diminiſhed. The other properties of this mixed gas are ſtill little known, which, when better ſtudied, may throw light on many intereſting chemical phenomena.

14. The direct and binary combination of ſulphur with hidrogen, is as little known, though it can be well proved that theſe two bodies are capable of uniting. It is certain that they are frequently united together, though, indeed, with ſome other matters, in the complicated compounds which belong to the vegetable and animal organization; but the direct and binary combination of hidrogen and ſulphur is effected by certain means, of which it is neceſſary to explain here the general theory and influence, though it does not take place but by means of ſeveral other different bodies which have not yet been treated of. Whenever naſcent hidrogen gas, that is to ſay, hidrogen, at the moment when it aſſumes the gaſeous form, is diſengaged from a compound, or a mixture, or from a combination holding ſulphur very much divided, it always carries off a certain quantity in ſolution. It acquires new properties, a much greater denſity, an extremely fetid ſmell, an horrid mephitiſm, the property of giving a blue flame and of depoſiting ſulphur in burning, which is alſo precipitated from it by contact of the air,

and particularly during its ſolution in water, &c. This laſt property, namely, its ſolubility, which has reſolved the problem of ſulphureous mineral waters, as I ſhall elſewhere ſhow, by referring to ſulphurated hidrogenous gas, in the articles where the bodies, which favour its formation, are treated of, leads us to treat of ſulphurated hidrogen, or the combination of theſe two combuſtibles, deprived of the gaſeous ſtate. This appears frequently to exiſt in organic ſubſtances; ſuch it is particularly in thoſe compounds which Berthollet has named *hidro-ſulphurets*, and of which I have treated in the fourth ſection. There are, alſo, circumſtances of which I ſpeak on the ſame occaſion, in which ſulphur, united immediately with hidrogen, forms a concrete hidrogenated ſulphuret, of an oily appearance, which the ſame chemiſt has obſerved at the bottom of ſome ſolutions of hidroſulphurets.

15. Sulphur does not unite with carbon in a direct manner, ſo that we are not really acquainted with carbonated ſulphur, or ſulphurated carbon. At whatever temperature theſe two ſimple bodies are treated, or mixed together, they do not combine. This combination is, nevertheleſs, met with in vegetable matters, and particularly in animal ſubſtances, with a third, and ſometimes indeed with a fourth body. It is even probable, that it is a carbo-ſulphurated compound which forms the baſe of a peculiar combuſtible, which has already been indicated

under the name of pyrophorus, and which will be treated of in the fifth ſection of this work.

16. Phoſphorus and ſulphur unite very well in all proportions. This union is effected by throwing ſulphur in powder on fuſed phoſphorus at the bottom of water; at the very moment of contact the ſulphur is abſorbed by the phoſphorus, and becomes combined and fuſed with it. The compound of ſulphurated phoſphorus, or of phoſphorated ſulphur, named in theſe two modes, accordingly as phoſphorus or ſulphur bear the larger proportion, is always more fuſible than either the two combuſtible bodies when ſeparate. The following are the principal facts aſcertained by Pelletier, relative to theſe combinations. Eight parts of phoſphorus and one part of ſulphur, form a yellow compound which remains fluid at 28 degrees of the thermometer of Reaumur. Four parts of phoſphorus and one part of ſulphur combined, remain fluid at 12 degrees. One part of phoſphorus and half a part of ſulphur retain fluidity at 8 degrees. Equal parts of theſe two bodies form a combination which does not become fixed till at 4 degrees. One part of phoſphorus and two parts of ſulphur, very eaſily combine under water by a mild heat; this remains fluid only till 18 degrees, and partly cryſtallizes at that temperature. One part of phoſphorus and three of ſulphur unite very well, the former abſorbing under water, the three parts of the lat-

ter added ſucceſſively one at a time. This phoſphorated ſulphur remains liquid at 30 degrees. All theſe compounds, as is evident, are more fuſible than phoſphorus itſelf, and much more fuſible than ſulphur; which manifeſtly depends on this, that they retain, in their combination, a greater quantity of caloric than each of them contains ſeparately. So that a ſlight refrigeration takes place at the moment when the combination takes place. That compound, which remains fluid till 4 degrees of temperature, appears, while preſerved under water, as a white, or ſlightly-opaque lemon-coloured oil. Theſe combinations may be made in the dry way, and in retorts, by collecting the product by diſtillation, in a receiver half full of water; they are fuſed with rapidity, and even with exploſion; it is, therefore, neceſſary to uſe much precaution in treating them. Thoſe which are formed with fuſed phoſphorus under water, by adding a ſulphur to it, are accompanied by ſwelling, and by jets thrown out of the veſſel, particularly if it be rather briſkly heated.

17. Sulphurated phoſphorus, or phoſphorated ſulphur, formed in the dry way, ſwells up when thrown into water; it diſengages globules of gas which have a fetid garlic ſmell, and are luminous in the dark; theſe globules are frequently inflamed ſpontaneouſly and with exploſion in the air. The water, which contracts in this caſe an acid quality, is manifeſtly decompoſed in this experiment, as will be mentioned elſewhere,

where, and it diſengages phoſpho-ſulphurated hidrogenous gas. It is evident, that the phoſphorus and ſulphur acquire, by their union, a ſtronger attraction for oxigen than they have ſeparately, ſince they are capable of carrying it off from hidrogen, and of decompoſing water. The very great combuſtibility of ſulphurated phoſphorus is turned to advantage in the preparation of the bougies, included in tubes of glaſs, which, when they are taken from them, after having broken the tubes, take fire the moment they acquire the contact of the air. On this property alſo are formed theſe bottles, containing fuſed phoſphorus, inflamed by a rod of red-hot iron, and quickly extinguiſhed, in which the ſulphureous matches, which are dipped in them, catch fire the moment they are drawn out into the common air.

18. It is very remarkable in the combination of ſulphur and phoſphorus, as well as in thoſe of the greater number of combuſtible bodies with each other, that they can exiſt very different in proportions of the two matters which are combined together, or in a great latitude of the relative quantities, whereas the combinations of each of theſe ſeveral bodies with oxigen, admit of only one conſtant limit in the proportions of each. This laſt property is always obſerved, and ſhould be oppoſed to that which I have juſt remarked, in the compounds of combuſtibles with each other, and in the combinations of burned bodies with the baſes, as will be explain-

ed more largely in the hiſtory of the ſalts, fifth ſection.

19. It is evident, from what has been ſtated, reſpecting the properties of ſulphur, placed merely in contact with the eight ſubſtances, of which the examination precedes the firſt article, that this combuſtible body, known as it is at preſent, has ſingularly contributed to the advancement of the ſcience, and to the explanation of a great number of natural phenomena; for it will be admitted, from the ſeries of articles compriſed in the following ſections, that nature employs ſulphur in a great number of its operations, preſents it under many forms among foſſils, charges with it the waters denominated ſulphureous, mineralizes with it the metals, cauſes it to paſs into the vegetable and animal fibres, and, in a word, exhibits it to chemiſts in an infinite number of combinations.

20. Mankind have uſed this ſulphur, which Nature preſents on all ſides, for a multiplicity of uſeful purpoſes. So numerous are the arts of which this ſubſtance forms the ſubject, the baſe, or one of the principal materials, that it would be ſuperfluous to attempt any enumeration in this place. This enumeration will be given in the ſeveral ſections of this work, whenever the uſeful applications of chemiſtry require it to be announced.

ARTICLE XI.

Concerning the Diamond.

1. IT appears at firſt extraordinary that the diamond, which has been ſo long placed in the rank of precious ſtones, or cryſtalline gems; that the diamond, one of the hardeſt and moſt inalterable bodies in nature, ſhould, at preſent, be reckoned in the number of ſimple combuſtible ſubſtances, next to ſulphur and phoſphorus. Bergmann has ranked it, in 1784, among the bitumens, acknowledging it to be an inflammable matter, though he had admitted ſeven years before, by placing it at the end of his analyſis of gems, two earths combined with this inflammable body, of which he ſeems to believe the diamond particularly formed: but it is neceſſary to obſerve, that he made his experiments only with the diamond powder of commerce, which is ſingularly impure.

2. Newton, conſidering they great refractive force of the diamond, conjectured that it muſt be combuſtible. Coſmo III. Grand Duke of Tuſcany, firſt cauſed experiments to be made at Florence in 1694 and 1695, by the members of the Academy del Cimento, from which it reſulted that, when treated with the burning mirror, it becomes tarniſhed, deprived of its poliſh, loſes weight, or is diſſipated without any reſidue or

trace. Many years afterwards, François-Etienne de Lorraine, afterwards Grand Duke of Tuſcany, and then emperor under the name of Francis I. made at Vienna a ſeries of eſſays, in which he ſaw that diamonds were deſtroyed by the mere heat of furnaces. Citizen Darcet afterwards proved, that they are deſtroyed even in crucibles of porcelain, when very cloſe. Macquer firſt, in 1771, ſaw the diamond ſwell, and burn with a luminous glory, or a very ſenſible flame. Rouelle the younger, Rouſe, Cadet, Mitouart, have eſtabliſhed, by many experiments, the volatilization, and combuſtion of the diamond. It is to Lavoiſier, that the laſt and the moſt accurate reſearches concerning the phenomena, and the products of this combuſtion are due.

3. The diamond has not yet been found but in ſome countries of the Eaſt Indies, particularly at Golconda and Viſapour. They are found of leſs beauty in the Braſils: it is ſaid, that they exiſt under rocks of granite, between beds of ochreous earth, which are always enveloped, or covered with an earthy, lamellated, and ſparry cruſt; ſometimes they are found rolled, and brilliant in waters. They are diſtinguiſhed, in commerce, into different ſpecies by their hardneſs, their tinge, their beautiful water, and their colour; becauſe there are ſome of them which are coloured like the cryſtalline gems. Some are veined, ſpotted, and clouded: it is aſſerted, that theſe laſt defects diſappear by heating the

diamonds,

diamonds, for ſome time, in very cloſe crucibles. All the differences here indicated, and even thoſe of form, do not conſtitute ſpecies, but mere varieties of the diamond.

4. There is no known body ſo hard as the diamond, ſince there is none of them which can act upon it by friction; it is impoſſible to grind, or poliſh diamonds, but by rubbing them againſt each other: by which means, diamond powder is obtained. Though very hard, the diamond is far from poſſeſſing the ſpecific gravity of the metals: according to Briſſon, its ſpecific gravity is from 3,5212 to 3,5310. Its form is almoſt always regular. It is found in a regular octahedron, which is its primitive form: that of its particles is the regular tetrahedron. That which is named the ſpheroidal diamond, has forty-eight curvilineal triangular faces, and owes this ſingular cryſtallization to a regular decreaſe, which Haüy has ſubmitted to calculation. The lapidaries, in cutting it, diſcover plates in the direction of which it is eaſier to divide it: it is this which they called ſplitting the diamonds. The hardeſt appear to be formed of contorted fibres: lapidaries call them diamonds of nature.

5. The diamond expoſed to light refracts it, and decompoſes it more efficaciouſly than any other tranſparent body. This is the property by which it pleaſes moſt; it ſparkles, with all the ſplendor of the rainbow, principally when its effects are multiplied by cutting, and the

number of the poliſhed facets with which it is incloſed. Thoſe which are cut in pyramids, on both ſides, bear the name of *brilliants;* and the diamonds cut only on one ſide, and flat on the other, are named *roſes.* The diamond appears to have the property of retaining light among its particles: when it is left ſome time, in the ſun, and then carried into a dark place, it is luminous, and, as it were, phoſphoric; it is, alſo, very ſenſibly electric by rubbing.

6. Caloric, accumulated in great quantity in the diamond, after having dilated it without fuſion, cauſes it, however, to boil ſlightly, to ſwell, and even to ſcorify in ſome points. It appears, alſo, to loſe a portion of its external brilliancy, to tarniſh, and even to become enveloped with a kind of blackiſh covering, when there is a little air in the apparatus. In a very ſtrong, and long continued heat, as that of the furnaces for porcelain, the diamond, though incloſed in crucibles of porcelain paſte, is volatilized, and diſappears, leaving the ſpace void, which it occupied in the middle of that paſte. This ſingular reſult, obtained by Darcet, and verified by Macquer, upon charcoal treated in the ſame manner, depends on the dilatation of the paſte by the ſtrong heat, and to the combuſtibility of the diamond, which is aſcertained beyond all doubt, by other experiments.

7. The diamond, which does not undergo any alteration in the cold in oxigen gas, is certainly capable of burning, even with flame and

decrepitation, when plunged therein very much heated, or environed with other combuſtible matters which can give heat to it. What happens in this kind of combuſtion is not exactly aſcertained. It may be effected, either by the aid of the rays of the ſun combined by a lens, and thrown upon the diamond, incloſed in a glaſs veſſel, filled with oxigen gas over mercury, or ſtill more commodiouſly, by cauſing very pure oxigen gas to paſs through a tube of porcelain, in which the diamond is kept ignited. Every fact proves that the product of this combuſtion is the ſame with that of carbon, as is evident, in treating the diamond in the air. It has been announced, in September 1791, that a diamond had been burned at Prague, by plunging it into a veſſel full of oxigenous gas, after having attached to it a ſmall portion of ignited iron wire, the combuſtion of which, excited by the oxigen gas, was afterwards communicated to the diamond, which burned with the greateſt ſplendor. It has been alſo announced that the diamonds of Braſil do not burn by this means. This experiment ought to be made uſe of, to determine what change the oxigen gas undergoes. Nothing happened in conſequence of this fine experiment, as M. Landriani has deſcribed it in his letter. (Annal. de Chimie, XI, pag. 156).

8. It is well proved, that the diamond, heated with the contact of the air, in the mere heat of the cupelling furnace, ſwells when red-hot,

commences by preſenting a colour more brilliant than the veſſel which ſupports it, and becomes environed with a luminous glory, or a true ſlightly greeniſh-white flame, and, when it has attained that temperature, ſoon diſappears in the air which environs it, continuing to ſparkle with the ſame ſplendor till its laſt particle diſappears. Theſe phenomena, ſeen, for the firſt time, by Macquer in 1771, afterwards confirmed by Darcet, Rouelle the younger, Roux, Bucquet, Cadet, Mitouart, Guyton, and myſelf, leave no doubt that the diamond undergoes, in this caſe, a real combuſtion. If the experiment be interrupted, after the flame has commenced, the cooled diamond is found to have loſt weight, and is frequently blackened at the ſurface. This laſt colour, which envelopes it like a covering, principally takes place when it is heated leſs than is neceſſary to burn it. If it be heated in retorts, it does not loſe weight, but in proportion to the quantity of air contained in the apparatus, as Lavoiſier has obſerved. This celebrated chemiſt, having expoſed diamonds, in bell-glaſſes full of air, reverſed on water, and on mercury, to the focus of a burning glaſs, always obſerved the volume of the air to be diminiſhed about a ſeventh, the diamonds to loſe weight, and, what is ſtill more remarkable, the atmoſpheric oxigen gas is converted into carbonic acid gas. In eſtabliſhing, at the end of theſe experiments, a compariſon between the effects of charcoal, and thoſe of the diamond, he ſhewed, even in

1792, that there was reaſon to infer that theſe two bodies have the greateſt and the moſt ſingular analogy in the products which they leave after combuſtion. It would be very aſtoniſhing if the diamond ſhould be pure carbon; and this, however, it will be neceſſary to conclude, if it ſhould be found, that the product of the combuſtion in oxigen gas be merely carbonic acid. Farther experiments muſt be made to juſtify this concluſion.

9. There is no known action between azote, hidrogen, carbon, phoſphorus, ſulphur, and the diamond. It is true that no accurate experiment has yet been made on this ſubject; perhaps, an attraction between phoſphorus and the diamond will be diſcovered. Hitherto, no combination of theſe two bodies with each other has been found. It is known that the powder of charcoal, in which diamonds are incloſed, in the middle of very cloſe refractory crucibles, enveloped in a covering which is fuſed into glaſs, by which the apparatus is found completely enveloped, defends theſe diamonds from all change by heat, and that this is the method which lapidaries make uſe of to take away ſpots from ſome diamonds.

10. The uſes of the diamond are not many; its beauty cauſes it to be particularly employed as an ornament, and as a part of dreſs; cutting and poliſhing adds to its ſplendor; its ſcarcity renders it of high price; and this is to luxury, as well as to ambition, a powerful motive for its

acquiſition. They are not employed in the arts, except to cut, faſhion, and grind glaſſes, and ſome hard ſtones, and to engrave on the ſame bodies.

ARTICLE XII.

Concerning the Metals.

1. I HAVE ranked the metals in this firſt claſs of chemical bodies, or among undecompoſed bodies, merely to complete the ſeries of ſimple combuſtible matters, which belong to this claſs. It would not be proper, beſides, to ſpeak of them here but in a general and rapid manner, ſimply to compare them with the preceding combuſtible bodies. The hiſtory of metals ought to differ from that of other ſimple bodies becauſe they comprehend a very great number of perfectly diſtinct ſpecies, to which there is every reaſon to believe that future diſcoveries will ſtill add others; and conſequently it will be ſufficient, if we here explain thoſe properties only which belong to the whole genus.

2. The metals are very diſtinguiſhable, and very diſtinct from all other bodies, by their perfect opacity, brilliance, or ſplendor, their conſiderable weight, and the ductility of ſome, or the facility of changing their form and dimenſions, without loſing their conſiſtence and tenacity, by mere preſſure; they are really combuſtible bodies, ſince they all combine with oxygen

igen, which they ſolidify, and ſince they all, during that combuſtion, burn with a flame, more or leſs brilliant, and a heat, more or leſs ſtrong.

3. Nature preſents them, either in maſſes, forming beds or veins, in the interior of the earth, or in diſſeminated portions, or in depoſitions, and ſuperficial incruſtations. They are found, alſo, in vegetable and animal combinations: rarely pure; frequently combined with each other, or combined with the combuſtible bodies formerly treated of; united with oxigen, or ſaturated in that ſtate of oxidation, with a number of burned matters, which will be treated of in the following ſections. The proceſſes to diſcover them, to extract them from the earth, to eſſay them, to obtain them ſeparate from their mineralizers, that is to ſay, from the different matters which are united with them, which conceal their properties by reducing them to the ſtate of ores, and laſtly, to purify them, belong to the very important chemical arts, of which I ſhall ſpeak in the ſection appropriated to the hiſtory of the metals in particular. I ſhall, alſo, in like manner, refer the claſſification of the numerous natural combinations which they form, and which will be one of the objects of the ſeventh ſection.

4. All the metals, reflect more or leſs light, and conſtitute mirrors, when poliſhed. All of them are, at firſt, dilated by caloric, permit it to paſs, more or leſs eaſily, as very good conductors, are fuſed, and flow when ſufficiently

penetrated with it; and at very different degrees of heat. Some of them are volatilized quickly, and others more difficultly. All of them, when cooled ſlowly after having been fuſed, cryſtallize in octahedra, or in cubes, or in forms which are derived from them. Thoſe which afford regular octahedrons, ſuch as are obſerved alſo in the native metals, have the regular tetrahedron for their integrant particle; in others, the cube is at once the primitive form, and that of the integrant particle.

5. All the metals, more or leſs heated, burn with flame and decrepitation in oxigen gas; they diſengrge from it light and caloric, and abſorb oxigen in different quantities, and adhere to it with very various forces; they each aſſume different proportions, according to the manner in which their combination with that principle is effected; they form either acids or oxides. The greater number of the preceding combuſtible bodies have more attraction for oxigen than the metals have, and can deprive them of it.

6. In atmoſpheric air, moſt of the metals undergo, but very ſlowly, a ſlight alteration at ordinary temperatures; ſome of them, however, are thus burned, and oxided very quickly. All of them, when heated conſiderably, are oxided with, or without flame, and decompoſe the common air by depriving it of its oxigen, and leaving inſulated the azote gas. Some of them might even be uſed as eudiometers.

7. The

7. There is not, in art, any known union between azote, hidrogen, and the metals; but no fact proves that this is impoſſible, or that it does not exiſt in Nature. There are, even, ſome facts which ſhow that certain metals may be diſſolved in hidrogen gas, and probably a much greater number will be hereafter found ſuſceptible of this kind of ſolution, which muſt modify the properties of hidrogen gas, as carbon, phoſphorus, and ſulphur do. If theſe combinations ſhould be diſcovered, they may be named metallic hidrurets, and hidrogenated metals, accordingly as the hidrogen, or the metal is in greateſt quantity.

8. Several metals are already known as to their property of uniting to carbon, and it is very natural to think that the greater number poſſeſs this property, and that it is not yet diſcovered, for want of ſufficient reſearch. When carbon enters into combination with a metal, which only takes place by fuſion, or at a high temperature which greatly ſoftens the metallic ſurface, the metals loſe the natural arrangement of their particles, and are changed in form, colour, ductility, weight, fuſibility, &c. If there be little carbon preſent, they are named carbonated metals; in the oppoſite caſe, they will be metallic carburets.

9. There is no known action of carbonated hidrogen gas on the metals; carbonated hidrogen is, perhaps, capable of combining with theſe bodies. Hidrogen having, beſides, more at-

traction for oxigen than moſt metallic ſubſtances have, it is evident, that their oxides ought to be decompoſed by hidrogen gas, or by the different hidrogenated combinations. This decompoſition is moſt frequently proved in treating the heated metallic oxides with hidrogen gas; by this means, they again paſs to the ſtate of metals, and water is formed by the union of the hidrogen with the oxigen of the oxides. Theſe decompoſitions ſometimes take place in the cold, and by ſimple contact.

10. Phoſphorus eaſily combines with all the metals, provided they are placed in a very divided ſtate, in contact with phoſphorus, when it is ſeparated from its compounds, and particularly from the phoſphoric acid in which it is employed. If there be little phoſphorus in theſe combinations, they muſt be named phoſphorated metals; if, on the contrary, they contain more of phoſphorus than of metal, they are metallic phoſphurets. All theſe compounds are more or leſs granulated, lamellated, brittle, fuſible, inflammable, ſometimes even by a blow, fetid by the contact of water, and of humid air. Phoſphorus, in this ſtate, loſes its luminous property, and even a great part of its combuſtibility. It is probable, that the metallic phoſphurets exiſt in Nature, and that they conſtitute certain ores, though this has not yet been verified by analyſis.

11. The action of phoſphorated hidrogen gas on the metals, has not been examined with ſuf-

ficient care; there is reaſon to believe, that theſe combinations exiſt even in Nature. The greater part of the metallic oxides are decompoſed by this gas, which, by bringing them again to the metallic ſtate, forms water, and phoſphoric acid in proportion as it carries off their oxigen.

12. Sulphur unites, in different proportions, with moſt of the metals. Thoſe which are very fuſible, become difficult of fuſion by this combination; on the contrary, it augments the fuſibility of thoſe which are refractory. The metallic ſulphurets are extremely abundant, and frequent in nature: they conſtitute the greater number of metallic ores. Frequently caloric drives off a portion, or the whole of the ſulphur which they contain. This is one of the proceſſes which is practiſed on a large ſcale, in ſome caſes, to procure the ſulphur, and, in others, to commence the ſeparation, or purification of the metallic ſubſtance. The metallic ſulphurets poſſeſs many other important properties which will be deſcribed under the article of each metal in particular. We ſhall be content with adding, in this place, that ſome of them are frequently very combuſtible, and that they abſorb oxigen ſo quickly that they may be uſeful in eudiometry; that they decompoſe water; and that, in this laſt caſe, ſulphurated hidrogen gas is ſeparated, of which theſe bodies are the moſt abundant ſource, &c.

13. Sulphurated hidrogen gas acts, in a very remarkable manner, on ſeveral metallic ſubſtances; by the ſlighteſt contact it colours them; in this caſe, it appears that the atmoſpheric oxigen unites to the hidrogen, and the metal to the ſulphur; thus metals, for a long time expoſed to this gas, become covered on their ſurface, by a cruſt of metallic ſulphuret; ſome other metals appear to abſorb it entirely, and to combine with it in hidro-ſulphurets. The effect of this gas is ſtill more marked on a great number of metallic oxides; ſome abſorb it entirely, and combine with it in ſuch a manner, as to form hidro-ſulphurated oxides; others decompoſe it, and are decompoſed, at the ſame time, more or leſs completely. Thus the whole, or merely a part of their oxigen, is united with the hidrogen, with which it forms water, whilſt the metal, diſoxidated, or leſs oxidated than before, is united to the ſulphur, and conſtitutes a ſulphurated metal. It is for this reaſon, that the greater part of the metallic oxides are very rapidly coloured, being rendered brown, or black, by the ſlighteſt contact of ſulphurated hidrogen gas. The waters, charged with ſulphurated hidrogen, produce the ſame effect.

14. There is no known combination between the metals and the diamond. Nevertheleſs, fuſed iron, flowing by the ſide of a diamond, heated red in a crucible, where it has been heated in the midſt of charcoal, has ſcorified, and, as it were, vitrified that part of the

diamond, and appears to be truly combined with it; thus ſeeming to announce an attraction between theſe two kinds of bodies; this fact deſerves the attention of chemiſts, and it is deſirable that it ſhould be verified by heating the various metals ſtrongly with the diamond.

15. There are few bodies which are ſo uſeful, and conſequently which are ſo much uſed as the metals. Neither are there any which have ſo much exerciſed human induſtry, and given birth to ſo great a multiplicity of different arts. The particular hiſtory of theſe bodies, deſtined to form the ſixth ſection of this work, preſents the uſes of each, and a ſhort notice of the ſeries of arts which are connected with the metals. It is ſufficient to remark here, that their chemical examination, ſo rich in numerous facts, and their treatment ſo varied in the great works and manufactories, have infinitely contributed to the perfection of human reaſon. This is well proved, by the manifeſt ſuperiority which thoſe nations, among whom the metallic arts are cultivated with moſt ſucceſs, preſent to the philoſopher, as well in their domeſtic enjoyments, as in their public proſperity.

END OF THE FIRST VOLUME.

R. Noble, Printer,
Old-Bailey.

15
14
18
47

Total

he Number of deaths registered in the

of Oswestry for the past three

months ~~&~~ being the first quarter of

69. amounted to 47 — or at the

nnual rate 26·8 for each 1000

the population. being a decrease

n the last quarter of 1868 of 6 —

There were 6 deaths from Zymotic

iseases during the quarter - 4 from

arlet Fever & ~~dropsy~~ or complications ; 1 from Typhus

& ain congestion & one from Hooping cough

seases of the Head-caused ~~4~~ 5 deaths 2 from

oplexy - and 3 in children from Hydrocephala

r water on the brain — Convulsions in infants 4

sions were the principal cause of mortality Consump

s than 15. 8 - from acute ~~dis~~ disease Bronchitis Inflam

[illegible]

2

Apoplexy. Hydrocephalus

4 Convulsions 4

Hydrocephalus 3

Apoplexy 2

Puerperal fever 1

7 / L4 Spinal Decay 6

2 Heart 3

Chest Dis. (Pleurisy 7

Acute Diseases of chest

8 8 8 !

7/18 8

32

Tabes Mesenterica 1

P Hepatitis 1

Cancer of Uterus 1

Dis of Heart 3

[illegible] 1

Gastro Enteritis 1

6

INCORRECT PAGINATION